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ANNUAL REPORT

1973

NATIONAL ENVIRONMENTAL RESEARCH CENTER
RESEARCH TRIANGLE PARK
NORTH CAROLINA

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Development
National Environmental Research Center
Research Triangle Park, North Carolina

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EPA has a clear mandate to carry out the environmental statutes enacted by Congress . . . In addition, I believe that EPA has a broader responsibility to help define, articulate, and give leadership to the environmental aspirations of our society.'' Russell Train—First speech as Administrator, delivered before the National Press Club in Washington, D.C., September 18, 1973.

PREFACE

The Environmental Protection Agency, as with other Federal organizations, receives direction from legislative mandates passed by Congress and approved by the President. Important then is an understanding of how well the purpose of this direction is achieved. This determination can best be made by reviewing programs in relation to the appropriate legislation. In this Annual Report for 1973 attention is focused on the research activities of NERC-RTP and their relationship to specific legislative acts applicable to NERC-RTP. Thus, in presenting a summary of our research accomplishments during 1973, the Report illustrates the responsiveness of this research to Congressional desires. We hope too, that in reading the Report you will understand better the role of Congress and the Executive Branch in establishing an environmental policy and the action taken by a Federal agency to fulfill the intent to this policy. Comments on the Report and our activities are welcome.

John F. Finklea, MD

John F. Finklea, M. D.
Director, NERC-RTP

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

THE ENVIRONMENTAL PROTECTION AGENCY's National Environmental Research Center at Research Triangle Park, NC, (NERC-RTP) constitutes one of the largest multidisciplinary research groups in existence concentrating its efforts on developing the bases for improving the environment of the United States. Basic research and development programs at NERC-RTP encompass air pollution, pesticides pollution, and radiation pollution; a special studies staff performs diverse technical investigations. This summary provides a brief discussion of the program areas, cites some of the major accomplishments during the period of this report, and indicates the direction of future research.

Air Pollution

Air pollution research and monitoring projects encompass a wide variety of scientific disciplines ranging from the elucidation of the effects of pollutants on human health to the evaluation of devices for measuring pollutant concentrations in the ambient air.

In the evaluation of measurement methods, NERC-RTP Laboratories conduct a continuing program to establish definitive requirements and test procedures to be used in determining whether new or different methods of sampling and analyzing the ambient air produce valid, legally acceptable data. Acceptable procedures may then be designated as "equivalent" methods. (Equivalent methods provide the same degree of measurement accuracy as the "reference" methods given in the regulations for primary and secondary ambient air quality standards.) In furtherance of this project, specific performance specifications and test procedures for measuring carbon monoxide, ozone, and sulfur dioxide were tested for workability and technical adequacy by NERC-RTP technicians and by a private, independent contractor. Reference materials (samples of known composition) were supplied to participants in collaborative testing of reference methods for measuring ozone and beryllium; significant progress was also made in the development of reference materials for ambient nitrogen dioxide measurements.

During the year, NERC-RTP began the preparation of guidelines for the development of regional quality assurance programs for use with the reference methods for new stationary sources; and with the reference methods for two hazardous pollutants, mercury and beryllium. Also, reference samples were developed for use in quality control programs of measurements of sulfur dioxide, carbon monoxide, and particulates in ambient air.

Reference methods used to characterize emissions were improved for Category I and II new source performance standards. (Category I sources include

Lamp method is used to analyze sulfur content of gasoline collected by National Fuels Surveillance Network.

steam electric power plants, cement plants, municipal incinerators, sulfuric acid plants, and nitric acid plants. Category II sources include petroleum refineries, primary lead and copper smelters, and asphaltic concrete plants.) Performance criteria were developed for extractive and *in-situ* instrumentation for determination of compliance with sulfur oxide, nitrogen oxide, and opacity standards for a number of Category I sources.

X-ray fluorescence methods for use in analyzing a number of possibly hazardous materials were developed, and improved sampling and analysis methods for polycyclic organic matter, asbestos, and mercury are being evolved. Particular research emphasis was placed on assessing levels of mercury that may have an adverse effect on human health.

Several special studies were conducted by NERC-RTP at the request of EPA's Office of Air Quality Planning and Standards to determine the ambient concentrations of significant pollutants—one of many instances of technical assistance being provided to other EPA components and to State air pollution control agencies.

Operational responsibility for the Continuous Air Monitoring Program (CAMP) stations in Philadelphia, PA, Denver, CO, and Chicago, IL, was transferred from NERC-RTP to the EPA Regional Offices in these cities. The transfer involved personnel and resources and included responsibility for the direction of the National Air Surveillance Network (NASN) monitoring program for total suspended particulates, sulfur dioxide, and nitrogen dioxide.

In the area of air quality simulation modeling, both for predictive and diagnostic purposes, the User's Network of Applied Models of Air Pollution (UNAMAP), a centralized computer facility, began operation. This network provides nationwide access by any user, public or private, to standardized and consistent model arrays to estimate concentration dispersion fields for six different source, receptor, dispersion, and topographic settings. Developmental work continued on improving and evaluating the sensitivity of simulation models for reactive and nonreactive species of pollutants for both local and regional applications.

Several important field investigations were undertaken during the year including a study in Denver, CO, conducted in cooperation with the EPA Region VIII Office and the Colorado State Air Pollution Control Office, to clarify the nature and source of the Denver "Brown Cloud"; a study in Houston, TX, and Phoenix, AZ, on photochemical oxidant air pollutants; and a study in St. Louis, MO, on photochemical oxidant and sulfur oxide air pollutants. Also in St. Louis, in preliminary experiments relating to the Regional Air Pollution Study (RAPS), an intensive aerosol characterization program was begun during the summer, and the difference in the solar radiation budget between a rural and urban site was investigated. Preliminary evaluation of the data indicates that the city of St. Louis received about 6.5 percent less solar radiation than in its rural surroundings, presumably because of the extinction of sunlight by air pollutants. RAPS, a major NERC-RTP research program, is designed to improve the techniques for developing least-cost air pollution control strategies for urban areas.

NERC-RTP established a comprehensive and integrated program to study the effects of aerosol composition on visibility. This program included field studies to examine specific instances of visibility reduction caused by aerosols, a project to develop a theoretical model of visibility degradation, a study of the effects of humidity on aerosols and visibility, and a study of aerosol formation as a function of reactant concentration. Construction of an aerosol generation facility was also planned.

Statistical, numerical, and experimental studies were undertaken to investigate the effects of air quality on meteorological parameters and climatology—and to assess the effects of meteorology and climatology on air quality. Wind tunnel modeling and cloud and rain-chamber techniques were used to determine the scavenging efficiency of precipitation on atmospheric aerosols, a process bearing heavily on the problem of acid rains.

The Community Health and Environmental Surveillance System (CHESS) program, a major NERC-RTP project that relates air quality to human health effects, was continued in 31 neighborhoods in 6 sections of the country—the interstate area of New York–New Jersey; the state of Utah; and the cities of Chattanooga, TN, Birmingham, AL, Charlotte, NC, and Los Angeles, CA. The health indicator used in the program included chronic respiratory disease in adults, acute lower respiratory disease in children, frequency of daily asthma attacks, pulmonary function tests of school children, cumulative residue of pollutants in body tissues, and daily aggravation of symptoms in individuals with pre-existing heart and lung disease. Results of the CHESS program for 1971-1972 for New York and the Southeastern areas revealed that, with respect to respirable-size particulates, the implementation of plans to improve air quality in the areas would provide obvious benefits to the study populations. Analysis of data and preparation of reports pertaining to nitrogen dioxide and oxidants for 1971-1972 was begun for the Los Angeles basin and for Chattanooga. Preliminary results from laboratory studies of controlled exposure of humans to oxidants indicate that ambient air concentrations of the pollutant in a number of cities may be sufficiently high to cause indentifiable chromosomal aberrations. The report *Health Consequences of Sul-*

fur Oxides: A Report from CHESS, 1970-1971 was published in May 1974.

Measurable progress has been achieved in developing the technology required to control air pollution from stationary sources in a timely and cost effective manner. On the pressing problem of fine particulate (matter less than 3 micrometers in diameter) control technology, potential areas of improvement of conventional devices have been defined, and laboratory testing of new concepts in detection and removal has been accomplished. Among the "conventional" devices, field tests show that properly designed and operated electrostatic precipitators can be more than 90 percent efficient on a mass basis in collecting all particle size fractions down to about 0.01 micrometer in diameter. Experimental work by NERC-RTP to aid in selecting optimum fabric filter cleaning methods was described in a report issued in early 1974. Test programs were initiated to evaluate two new particulate control devices, the sonic agglomerator and the steam-hydro scrubber; feasibility studies were completed on the use of charged droplets and condensation effects to improve fine particle collection.

The control of sulfur oxides has been a major problem of concern in efforts to improve air quality. The flue-gas-cleaning demonstration projects that are presently underway are expected to provide removal efficiencies ranging from 60 to 97 percent for these pollutants. The technical feasibility of removing inorganic sulfur from coal was proven in both laboratory and bench-scale tests; design of a pilot-plant-size operation has begun. Support for coal gasification and conversion processes and for versions of fluidized-bed combustion of coal and residual oil to reduce emissions (particularly for steam and power generation) has continued.

Techniques were developed for the reduction of nitrogen oxides emissions from combustion processes by as much as 50 percent in commercial coal-fired boilers. Commercially feasible means of reducing carbon monoxide, hydrocarbons, and particulate emissions from coke ovens by 90 percent were also demonstrated.

The NERC-RTP intramural capability to support control technique development programs took a significant step forward with the installation of the first aerodynamic test facility specifically designed for studies requiring large gas volumes (up to 15,000 cfm), carefully controlled velocity profiles, and test materials of known chemical composition. A research prototype lidar (laser-radar) system designed specifically for the measurement of particulate emissions from stationary sources was obtained, and a new long-path irradiation chamber system capable of the resolution of fractional parts per billion of ambient air pollutants began operation.

Improved optical measurement instrumentation has been developed for determining concentrations of regulated pollutants emitted by on-the-road vehicles. Extensive research was accomplished on sampling techniques for particulate emissions from light-duty vehicles using leaded and non-leaded fuels in vehicles with and without catalytic devices.

Analyses of some 1500 samples of fuels and fuel additives were completed, and some certified fuel standards were developed. NERC-RTP participated in a cooperative test of the trace element content of fuels with approximately 50 public and private laboratories using various measurement methods.

Currently, more than 325 additives used in gasoline have been registered in a number of chemical classifications. Detailed characterization of vehicle exhaust products resulting from combustion of fuels with and without additives and of products eminating from catalytic control devices and alternate power systems has resulted in a reassessment of the public health benefit related to the use of oxidation catalysts on mobile sources because of the attendant increase in levels of potentially hazardous, non-regulated emissions.

Scientific summary documents, which contribute to the scientific knowledge base necessary for administrative decisions regarding the need for control of a pollutant and indicate the strategy necessary to achieve that control, were initiated or completed for a number of pollutants. This documentation of pollutant characteristics leads to the issuance or revision of air quality criteria, which are compilations of the latest available information on the sources, prevalence, and manifestation of recognized air pollutants. During Fiscal Year 1974 for example, intramural review of the effects of sulfur oxides on vegetation led to revision of EPA's Air Quality Criteria for Sulfur Oxides, which led to a revision of the ambient air quality standards for that pollutant. By arrangement with the National Academy of Sciences (NAS), review documents for vapor-phase organic matter, chlorine, selenium, copper, zinc, arsenic, and the platinum-group heavy metals are being developed. With respect to the timely review of criteria documents (a requirement of the Clean Air Act of 1970), NAS is also preparing reviews on carbon monoxide, photochemical oxidants, nitrogen oxides, and fine particulate matter.

Pesticides Pollution

A significant portion of NERC-RTP pesticide research is directed toward evaluating the health effects of pesticides and their residues on laboratory animals and ultimately on humans. For example, high concentrations of an experimental organophosphate insecticide was found to cause irreversible paralysis in animals. The significance to humans of this finding will be evaluated using a newly developed, more sensitive procedure for determining low-level organophosphate exposure.

It was also found that, among pesticides tested in animals using an electroencephalograph, carbanyl caused changes in brain wave patterns and changes in behavior in primates at a concentration that approximates the incidental or background exposure levels experienced by humans. The significance of these findings with respect to humans is under active investigation.

During Fiscal Year 1974, all pesticides laboratory functions were consolidated at NERC-RTP from Perrine, FL, and Chamblee, GA. This transfer meant that not only were better accommodations provided and more efficient and economic operations made possible, but a significant element of increased safety for operating personnel and for experimental animal colonies was also achieved.

Radiation Pollution

Research activities at NERC-RTP included the investigation of both ionizing radiation and nonionizing electromagnetic radiation effects using laboratory animal models. Ionizing radiation research programs were confined to tritium and krypton-85, two major effluents from the reprocessing of nuclear fuel. Nonionizing radiation research (part of a multiagency control program) investigated potential detrimental effects of environmental exposure to radio and microwave frequencies.

Unique exposure facilities for the investigation of biological effects of exposure to radio frequency and microwave radiation were constructed at NERC-RTP. These facilities were used in studies that demonstrated the production of chromosome aberrations in mammalian cells caused by microwave radiation. Future efforts will include research on the teratologic and neurobiologic effects of nonionizing radiation.

Humans are exposed to environmental tritium from conception throughout their life span. A long-term dose/response study of female rats continuously exposed to tritiated water (HTO) over the gestation period and of their off-spring demonstrated harmful effects at concentrations approaching existing standards for exposure of human populations to tritium. Research into the harmful effects of krypton-85 on laboratory animals was continued with attention directed toward its cancer-causing properties.

Research on the health effects of synergistic pollutants was also continued. A study of the long-term effects of continuous exposure to lead combined with tritium revealed a tendency toward birth anomalies in laboratory animals.

Special Studies

During the period of this report, NERC-RTP continued its involvement in a host of international activities in cooperation with agencies such as the World Health Organization, the World Meteorological Organization, the Organization for Economic Cooperation and Development, and the North Atlantic Treaty Organization and with individual countries such as France, Poland, Pakistan, the United Kingdom, and India. A broad spectrum of involvement has resulted in technical assistance programs as well as scientific research in the fields of health effects research, source monitoring, pollutant dispersion modeling, and control technology. Cooperative research agreements in specified areas of environmental pollution included bipartite projects with the Federal Republic of Germany, Japan, and the Soviet Union and a tripartite project with Sweden and Japan.

NERC-RTP research capabilities were also focused on environmental problems related to the desire to again become self-sufficient as a nation in energy production. Substantial financial resources were allocated to the study of the impact of alternative power production strategies on human health—particularly regarding the increased levels of sulfates, nitrates, and total respirable particulates emitted as certain fuels are burned. A major objective is the development of more precise measurements of human exposure in situations of normal activity to permit the establishment of relationships between health effects and air monitoring data and to allow closer coordination between field epidemiological efforts and controlled laboratory studies.

Extensive support in resources and data was provided to the Energy Research and Development Program Task Force, a concerted, cooperative effort by Federal agencies to plan the Nation's energy future. A series of model environmental research and development activities were formulated by EPA to coincide with the development of new energy production technology. The models allow for an iterative process of environmental assessment and control technology development from the early stages of new technology conception through final demonstration and commercial application.

INTRODUCTION

INTRODUCTION

The National Environmental Research Center at Research Triangle Park, North Carolina, is a highly specialized facility in which multi-discipline research programs directed toward solving environmental problems are conducted.

THE ENVIRONMENTAL PROTECTION AGENCY conducts its activities under the auspices of several legislative mandates. Of these, four give direction to EPA's research programs carried out by the National Environmental Research Center at Research Triangle Park (NERC-RTP):

- Clean Air Act.
- Federal Insecticide, Fungicide, and Rodenticide Act.
- Federal Food, Drug, and Cosmetic Act.
- Public Health Service Act.

This Report, in describing the Center's research activities during 1973, relates how these programs are supportive of the mandates expressed in these Acts. Accordingly, the legislative mandate portion of the Report summarizes these Acts and the NERC-RTP programs directly supportive of them. The last section of the Report describes the NERC-RTP's scientific program in detail and its relationship to specific sections of the Acts. The Executive Summary briefly discussed the highlights of the Center's activities in 1973. This section continues with a general discussion of the Center—its mission, research program, and summary of resources. The Report covers the activities of the Center for the period January through December 1973. A supplement to the Report will be published listing the publications of the Center Staff.

Mission

The National Environmental Research Center at Research Triangle Park has the primary responsibility within the Environmental Protection Agency for the conduct and management of research and related activities pertaining to air pollution. In addition, the Center has responsibilities for carrying out research in the fields of pesticides and radiation. In general, Agency research related to environmental media other than air is performed by EPA at other National Environmental Research Centers. Also, in the interest of maximizing the scientific resources available to the Agency as its research and development operations evolve, responsibilities for research in air pollution effects with direct implications for non-human life and in the economic costs to the nation have gradually been transferred to those other Centers.

NERC-RTP is the corporate successor to preceding Federal research organizations that have evolved as a result of the nation's growing concern about air pollution over the last 20 years. Accordingly, the focus of NERC-RTP's objective generally is reflected in the stated purpose of the Clean Air Act; its research is tied to the statutory mandates of that Act as well as of newer legislation pertaining to pesticides and radiation.

The underlying purpose stated by the Clean Air Act is to protect and enhance the quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population. With this now broader mandate, the Center's mission can be paraphrased so as to protect and enhance the quality of life and the productive capacity of the nation's population. Recognizing the overwhelming technical problems and economic costs to the nation posed by a purpose of this lofty dimension, and to ensure that solutions advanced for dealing with those problems would be meaningful. Congress has stipulated other action purposes for the Act, the aims of which are to accelerate a national research and development program and to provide technical assistance to state and local governments. The mechanisms mandated by Congress for achieving the nation's environment-related goals rely heavily on the use of standards to be promulgated by the Agency. Such standards are applicable specifically to the offending sources and are designed to limit their emissions in accordance with appropriate environmental goals. To ensure relevancy for the emission standards, particularly where the problem is general and widespread, standards reflecting the environmental goals are required to be established by the Agency. The standards limiting emissions from the sources must reflect both the cause-and-effects relationships and the technological feasibility of their implementation. The scientific knowledge necessary to define the environmental goals, the establishment of the role of emissions as they relate to these goals, and the engineering capability to ensure availability of control technology at reasonable costs in societal, cultural, and economic consequences are essential to the mission of NERC-RTP.

The conduct of research supporting the development of a reliable monitoring and surveillance capability—for following the progress in attaining the environmental goals and ensuring compliance with the source standards—is ancillary to the Center's mission. Scientific knowledge necessary to define the environmental goals includes an ability to assess the impact of environmental pollution on health and welfare parameters as the following objectives relate to this need:

- Identification of the health and welfare indicators of environmental pollution.
- Identification of the chemical and physical nature of the environmental pollutants responsible for adverse effects.
- Development and application of measurement technology to establish pollution levels and define exposure patterns.
- Establishment of dose-response relationships and the mechanism of the pollutant action on the receptor.

To define the relationships between polluting sources and the environmental exposure pattern, the Center's mission includes the following objectives:

- Development and application of identification and measurement technology to characterize the chemical and physical nature of source emissions to the environment.
- Establishment of the patterns of movement of pollutants in the environment and the role of environmental factors in their transport.
- Definition of the nature and expense of the chemical and physical alterations that attend the movement of pollution through the environment.
- Development and validation of methods for simulating environmental exposure patterns and predicting optimum control strategy.

The engineering capability to control the emissions of environmental pollutants involves the following Center objectives:

- Characterization of pollutants.
- Development of laboratory and pilot-scale techniques and hardware for eliminating or minimizing emissions.
- Construction of plant-scale demonstration projects to assess the effectiveness of control techniques.

Surveillance and monitoring objectives relate to the development and application of the following parameters:

- Field-worthy techniques for large-scale population surveys to ascertain the benefits resulting from the control of environmental pollution and to determine the soundness of the standards upon which the controls are based.
- Measurement methodology for monitoring the impact of pollution controls on environmental exposure patterns.
- Measurement methodology for monitoring compliance with emissions standards and surveillance for new pollutants resulting from control operations.

A major function of the Center is the documentation of the scientific and engineering knowledge resulting from the conduct and management of research related to the above objectives to provide information for policy decisions at the Agency level.

NERC-RTP Research Program

The National Environmental Research Center at Research Triangle Park conducts research and related functions necessary for the fulfillment of the primary mission of the Environmental Protection Agency. This mission is to protect the public health and welfare by the establishment and enforcement of environmental quality standards. The research necessary for the development and promulgation of those standards is the responsibility of the Agency's Office of Research and Development of which the NERC-RTP is a major component. Research, and its auxiliary undertaking of environmental surveillance is essential to an appreciation of the complex and variable factors upon which environmental improvement depends.

Effective and rational standard-setting and enforcement require sound and relevant data on pollutants that are being introduced into the environment and on their impact on ecological stability, human health, and other factors important to the well-being of our society. Another obligation of research and development is to provide to the public and private sectors the technological know-how to comply with regulatory statutes. All research and technological advancement studies are conducted with the expectation of application in problem solving. Specifically, NERC-RTP has the overall responsibility for the direction and conduct of EPA's research and development programs related primarily to effects of air pollutants on health, and to the understanding of the physical and chemical processes operating during the emission, transport and transformation, and reception stages of the air pollution cycle. These programs are an integral part of EPA's closely coordinated total research program that strives to achieve a synthesis of knowledge from the biological, physical, engineering, medical, and social sciences that can be interpreted in terms of total human and environmental needs.

The NERC-RTP research program is in direct response to the language and intent of several Congressional mandates, specifically the Clean Air Act (and amendments). The Public Health Service Act; the Food, Drug, and Cosmetic Act; and the Federal Insecticide, Fungicide, and Rodenticide Act. The activities of five of the Center's eight major units (i.e., seven Laboratories and the Special Studies Staff) are undertaken exclusively, however, under the authority of the Clean Air Act. Results of the Center's research on the impact and the cause-effect relationships of pollution problems provide a range of knowledge necessary in the establishment of standards. The research development of pollution control technology provides pollutant emitters with the means for compliance with air quality standards, and the Center's monitoring capability provides a check on compliance with the standards.

NERC-RTP conducts research on a broad environmental basis to provide EPA with a sound scientific basis for control of environmental pollutants that adversely affect human health and welfare.

These programs emphasize the following major research activities:

- *Exposure and Source of Exposure*—These activities include development and standardization of techniques for measurement of pollutants, both at their source and in the ambient environment.
- *Effects of Exposure*—This work includes quantification of the effects of exposure to environmental pollutants on both health and welfare (including the development of techniques for assessing effects).
- *Stratgey*—This research includes development of predictive models for environmental levels of pollutant emissions, reflecting transportation and removal processes.
- *Prevention of Exposure*—Activities in this area include development of cost-effective control technologies.
- *Pollutant Characterization*—Efforts include preparation of briefing reports, scientific summary documents, and criteria documents.

The development and standardization of techniques for the measurement of pollutants both at their source and in the ambient environment are necessary for accurately defining the exposure and its source. Standards and regulations cannot be established until the extent and source of an exposure are identified. At the Center, techniques are being developed and standardized for defining both air quality and emissions. Emphasis will continue to be placed on gathering valid air quality and related data and on developing (refining) methodology for measuring pollutants. The chemical and physical transformations that pollutants undergo from source to receptor in the atmosphere are also being studied. Specialized monitoring and technical assistance services are provided to EPA Regional Offices and local air pollution control agencies in their endeavors to identify pollutants and their sources. The nationwide fuel surveillance network is operated to assess the potential impact of emission products from various fuel components and from various emission control devices on atmospheric reaction processes. Exposure of various materials to pollutants is also an important aspect of this research area. Environmental samples are analyzed for a variety of trace metals and other pollutants, requiring development and

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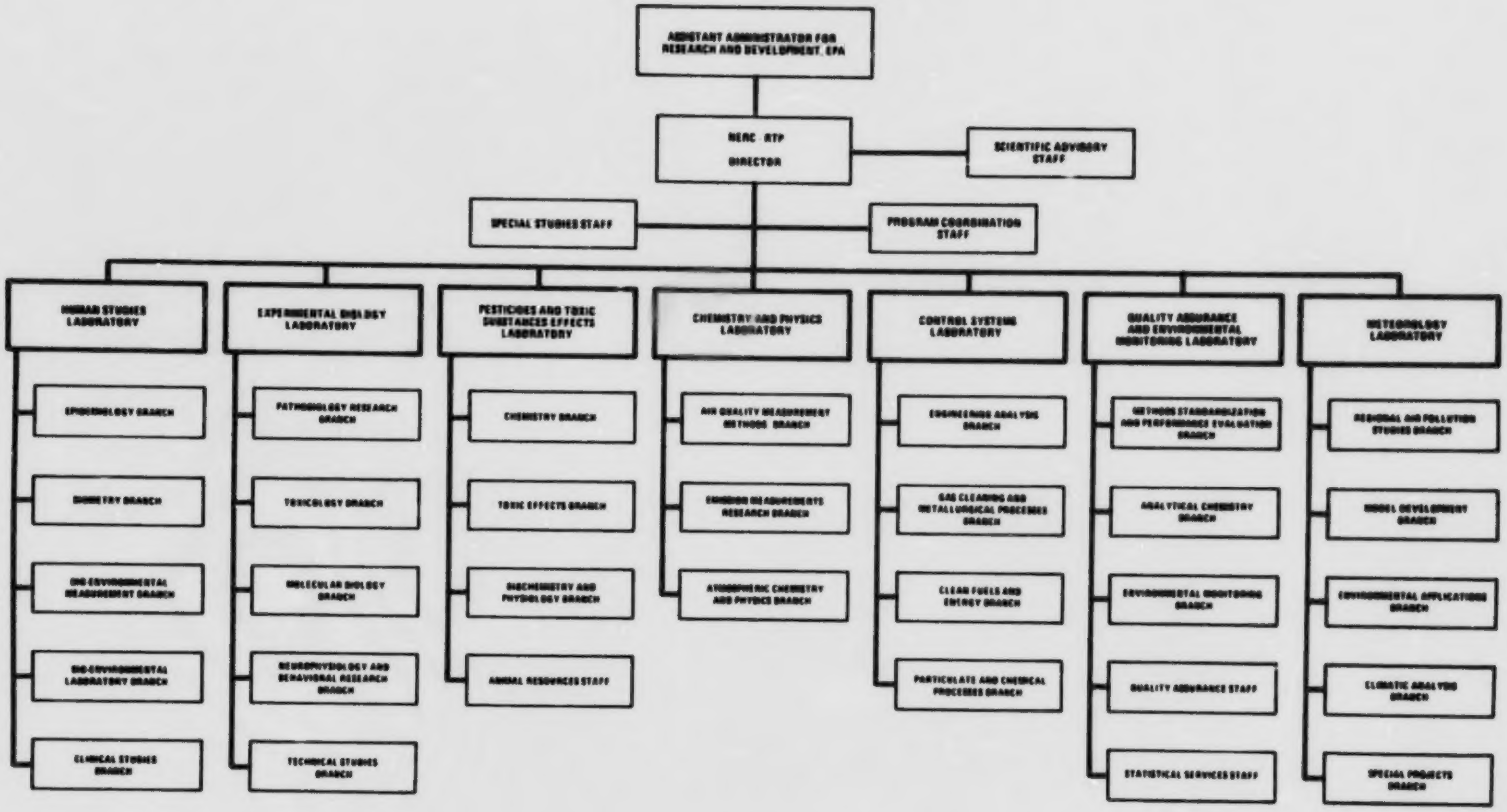
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standardization of monitoring equipment for specific elements.

It is important that standard methodology and adequate quality control be used to ensure the production of unimpeachable data and to maximize the validity and comparability of those data. Once the exposure to harmful substances and the sources of exposure are established, one major building block has been completed in the foundation of knowledge needed for making far-reaching national decisions on environmental control.

Another body of knowledge important to EPA in establishing and enforcing standards is the research concerned with the manner in which environmental pollutants (singly or in combination) cause specific undesirable health effects. This research includes animal studies, human clinical studies, and epidemiological studies on human populations. Major emphasis is placed on the collection of sufficient information for formulating environmental control strategies and thus providing bases for establishing national emission standards for pollutants or source categories that endanger human health or welfare.

The Community Health and Environmental Surveillance System (CHESS) is a national program of standardized epidemiologic studies organized within the past 3 years. The program is designed to measure environmental quality as it relates to chronic and acute health indicators in sets of communities representing exposure gradients to common air pollutants including particulates, sulfur oxides, nitrogen oxides, and photochemical oxidants. The CHESS program is essential in evaluating existing environmental standards, in obtaining health intelligence for new controls, and in documenting the health benefits of air pollution control.

Clinical research is being conducted in the area of exposure effects to obtain data on gaseous and particulate air pollutants relevant to the development of standards for the protection of human health and welfare. These studies are supportive of the standard-setting processes in the following ways:

- Validating data from human studies.
- Providing clues to new human studies.
- Indicating the potential harmful effects of new pollutants.
- Ascertaining the adequacy of safety margins through interaction studies.

A specific research area in the study of pollutant effects on human health and welfare is the research pertinent to providing data necessary for the intelligent assessment of the hazards to human health of exposure to pesticides, toxic substances, substitute chemicals, and combinations of these with each other and with other environmental factors. To obtain these data, toxicity studies are conducted in which various animal species are used as models. Methods for measurement of human exposure to pesticides and toxic substances are developed and improved, and a quality assurance program is conducted to ensure the accuracy of analytical results. The studies are concerned with identifying pesticides, their metabolites, and any adverse effects on normal biological functions. In these subject areas, research provides data needed by the Agency in meeting its legally mandated responsibilities in registering, labeling, setting of tolerances for, and limiting the misuse of pesticides.

Results of the Center's research on the effects from pollutant exposure are used in formulating and revising environmental quality criteria. The epidemiologic studies have been oriented toward defining environmental hazards and providing data on which to base standards. Biological research is designed to detect, define, and quantify the effects of environmental pollution. Collectively, the data generated by the Center's research on exposure effects form a major part of the information system that the Agency uses to set and enforce standards.

Relevant to the Agency's need to make control decisions is the information derived from the meteorological aspects of air pollution, including theoretical and experimental studies of the physical properties that affect the transport, diffusion, transformation, and disposition of air pollutants in and from the atmosphere. Through this research, techniques and methods to forecast potential air pollution episodes are improved. Analytical diffusion models are developed to predict the temporal and spatial distribution of air pollutants; they are also useful for pre-evaluating proposed air pollution control strategies. Studies are also conducted on the effects of air pollutants on the geophysical processes of weather and climate as well as on the energy balance of the earth-atmosphere system. The Center's research program also includes development of remote-sensing techniques for measuring meteorological parameters in urban areas.

Chamber and field studies are used to investigate physical and chemical characteristics, transformations, and effects on materials of emissions of sulfur oxides, carbon monoxide, nitrogen oxides, hydrocarbons and other organics, and their role in producing sulfates, nitrogen dioxide, nitrates, ozone, organic aerosols, and other finely divided particulate materials in the atmosphere. Because the consequences as well as the fate of environmental pollution can be anticipated from this and other information, the Agency can develop strategy to be used in its program of establishment of enforcement standards.

The Center's fourth major area of emphasis, prevention of exposure, can only be accomplished through the development of the technology required to control air pollution sources in a timely and cost-effective manner. The Agency does not stipulate the control technology to be used to meet the standards it has set; however, the Agency is required by law to publish control technique documents before it sets air quality standards. In other words, EPA must identify the means of achieving a standard before it sets the standard. Thus, much research is needed to develop control techniques that reflect the best available technology. A large part of the Center's research effort is concerned with the conduct, direction, and management of engineering research, development, and demonstration programs leading to the abatement of air pollution from major stationary sources. Laboratory activities encompass development and improvement of control devices such as scrubbers, filters, and electrostatic precipitators; complete effluent gas-treatment processes; combustion methods and equipment; fuel preparation technology; and associated sampling and analysis instrumentation systems. Improved control technology must be developed if new source performance standards are to have their intended effect and hazardous pollutants are to be controlled.

Another important element of control in the area of exposure prevention is the Fuel and Fuel Additive Registration program. The program consists of registering information on the chemical composition, purpose of use, and recommended concentration of additives used in motor gasoline that is introduced into interstate commerce. Fuel and fuel additive manufacturers are required to provide usage data quarterly for registered additives as well as information concerning the mechanism of action, effects on exhaust composition, and toxicity of the resultant exhaust products, if known. There are also protocols to assess the effect of fuel components on control device performance, which will result in information to allow the control or prohibition of fuel components or additives pursuant to the 1970 Clean Air Act Amendments in a time frame to ensure public safety and satisfactory performance of advanced automotive control systems.

A major effort in the Center, which results from the previously described research programs, is the preparation of briefing reports, scientific summary documents, and criteria documents that are required by the Clean Air Act Amendments. According to the law, the Administrator is required (from time to time but as soon as practical) to develop and issue to the States such criteria of air quality as in his judgment may be requisite for the protection of the public health and welfare. Such criteria shall reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on health and welfare which may be expected from the presence of an air pollution agent.

Pollutant characterization is an attempt to define the biologic effects of specific air pollutants on humans, animals, and vegetation, as well as nonbiologic effects such as modification of visibility and deterioration of materials. Characterization also includes gathering qualitative and quantitative information on the sources, form(s), reactivity, methods of collecting and quantitating, and strategies for controlling pollutants. In promulgating standards, the legally defensible basis must include scientifically sound assessment of comprehensive scientific data as reported in criteria documents. Associated position papers are also required to identify the need for additional research for producing adequate criteria for issuing or revising standards. Position papers (or scientific summary documents) are also developed for non-criteria pollutants to indicate the need for control and to recommend control strategy.

The effort of NERC-RTP in this area consists of collecting, reviewing, evaluating, comparing, summarizing, and interpreting pertinent information and literature to prepare criteria documents, briefing reports, and scientific summary documents on noncriteria pollutants. In this preparation, the data generated by the entire research program of the Center converge with all other available literature and research and form the basis needed to produce scientifically sound documents. The Center contracts with authoritative sources—one being the National Academy of Sciences—to review the information that is available on some issues. Center personnel then use these reviews in the assessment of the problems and in the development of pollutant characterization documents. These documents form a major component of the data base used by the Agency in making decisions on control and in deciding upon actions to be initiated.

The Center also provides assistance to the NATO Committee on the Challenge of Modern Society (CCMS), the Organization for Economic Cooperation and Development (OECD), and the World Health Organization (WHO) in developing air quality guideline documents as well as updating annually the information on primary ambient air quality criteria and hazardous pollutants.

LEGISLATIVE MANDATES

LEGISLATIVE MANDATES

ACTIVITIES OF THE NERC-RTP ARE EITHER in response to explicit mandates given in legislative acts or derived from language that requires the initiation of certain programs to carry out the intent of those mandates.

Illustrated in Tables 1 and 2 below are the resources of manpower (i.e., man-years and funds) that the several Laboratories of the Center have been allocated to carry out particular portions of the relevant Acts. Tables 1 and 2 are followed by a brief narrative description of each Section of the Clean Air Act and the specific responses of the appropriate Center units.

Clean Air Act

Activities of NERC-RTP units are responsive to at least 13 Sections of the Clean Air Act: 103, 104, 108 through 113, 202, 211, 303, 312, and 313. The following portion of this section of this Report outlines each of the Sections and relates them to the activities of NERC-RTP laboratories.

SECTION 103: "RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES"

The essential feature of Section 103 is the requirement for EPA to establish a national research and development program for the prevention and control of air pollution. In addition to the conduct of in-house research studies, surveys, etc., the requirements include provision of assistance to other public and private agencies and institutions to conduct experiments, studies, demonstrations, and training activities, as well as technical services relating to the causes, effects, extent, and control of air pollution. To help meet these requirements, the Act authorizes EPA to establish technical advisory committees; to cooperate with and utilize the resources of other Federal, public, and private facilities; to make research grants and contracts; and to develop practical processes and methods for air pollution control. EPA is to emphasize short- and long-term effects of air pollutants on health and welfare by epidemiological, clinical, and laboratory studies.

Table 1 indicates that the largest category of activities at NERC-RTP is that which involves carrying out the mandates imposed by this Section of the Clean Air Act. All but one of the laboratories are involved to some degree; over 90 percent of the resources of the Human Studies Laboratory (HSL) and the Meteorology Laboratory (ML) are so committed.

Research activities conducted at NERC-RTP are based on explicit environmental mandates of the Congress of the United States.

Table 1. SUMMARY OF RESOURCES EXPENDED BY NERC-RTP TO MEET LEGISLATIVE MANDATES OF CLEAN AIR ACT FOR FISCAL YEAR 1974

($\$10^3$/man-years)

Section of Act	Laboratory[a]								Total
	OD	SSS	HSL	EBL	CPL	QAEML	ML	CSL	
103		156/3	8461/104	1896/20	536/5	833/28	5940/49	4030/24	21,852/233
104								3546/21	3,546/21
108		158/3			1587/23	90/3		1934/11	3,769/40
109					562/9				562/9
110					2393/13	1182/14	275/12	1934/11	5,784/50
111					1847/17	405/10		3675/22	5,927/49
112					330/5	274/8		967/6	1,571/19
113						103/3			103/3
202					636/13				636/13
211		718/12			780/5	225/1			1,723/18
303							36/0		36/0
312								32/0	32/0
313		10/1			59/2	112/6	50/0		231/9
Total	637/14								46,409/478

[a] Office of Director (OD), Special Studies Staff (SSS), Human Studies Laboratory (HSL), Experimental Biology Laboratory (EBL), Chemistry and Physics Laboratory (CPL), Quality Assurance and Environmental Monitoring Laboratory (QAEML), Meteorology Laboratory (ML), Control Systems Laboratory (CSL).

Table 2. SUMMARY OF RESOURCES EXPENDED BY NERC-RTP TO MEET LEGISLATIVE MANDATES OF PHSA, FIFRA, AND FDCA[a]

($\$10^3$/man-years)

Act	Office of Director	Human Studies Laboratory	Experimental Biology Laboratory	Pesticides and Toxic Substances Effects Laboratory	Total
PHSA (Section 241)	78/2	299/9	1180/47		1557/58
FIFRA and FDCA	125/3			3141/91	3266/94

[a] Public Health Service Act (PHSA); Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); Federal Food, Drug, and Cosmetic Act (FDCA).

The Special Studies Staff (SSS) is concerned with the preparation, assessment, and dissemination of scientific and technical documents and publications related to air pollution research and control activities impinging upon the total research and development program, as well as on specific aspects commensurate with several provisions of this Section of the Act.

The effort of the Chemistry and Physics Laboratory (CPL) in this area deals primarily with studies relating to analytical methodology and atmospheric chemistry research.

The Control Systems Laboratory (CSL) conducts research to characterize emissions of pollutants, evaluate control technology, predict future needs, and develop and demonstrate the most promising and cost-effective control methods for stationary sources.

The Experimental Biology Laboratory (EBL) investigates the effects of gaseous and particulate pollutants on biological species, i.e., whole animal, organ, cellular, and sub-cellular components. Particular emphasis is given to effects on pulmonary defense mechanisms and pulmonary carcinogenesis and on the influence of interactions between coexisting pollutants and various physical factors upon these responses.

The development and conduct of studies designed to define relationships between environmental pollutants (singly or in combination) and specific undesirable health effects is the prime objective of HSL activities. Emphasis is given to the development of bases for ambient air and emission standards compatible with desirable aspirations for human health and welfare, and an evaluation of the health benefits that could be achieved. The assessment of adverse health effects and the economic costs that might result from any future revision of air quality standards is also a part of the HSL program.

The activities of ML focus upon research relating to the transport and dispersion of air pollutants, their effects on weather, visibility, and climate; and the relationship between weather factors and pollution. Dispersion model development and climatic analysis investigations improve understanding of the physical processes involved in (1) the relationships between source strength and receptor dosage, (2) the ultimate disposition (fate) of pollutants in the atmosphere, and (3) the delineation of a national climatology of the potential for adverse accumulations of air pollutants.

QAEML engages in the evaluation, testing, and standardization of methodologies for surveying the extent of air pollution as well as in the development of quality control procedures to ensure comparability of data wherever collected in the United States and for whatever purpose.

SECTION 104: "RESEARCH RELATING TO FUELS AND VEHICLES"

Section 104 charges EPA with the responsibility for conducting and supporting research into the development, laboratory and pilot testing, and demonstration of improved methods for the prevention and control of air pollution from combustion of fuels.

Activities by CSL under this mandate include the development of techniques for the reduction of nitrogen oxide emissions from combustion processes and the demonstration of commercially feasible means for the reduction of significant pollutants from coke oven emissions. Possibilities for effective, low-cost processes for cleaning coal are of current concern.

SECTION 108: "AIR QUALITY CRITERIA AND CONTROL TECHNIQUES"

EPA is required by Section 108 to ascertain those pollutants judged to have an adverse effect on public health and welfare and maintain an up-to-date list that it publishes from time to time. Air quality criteria for these pollutants must then be issued presenting the latest scientific knowledge on the kind and extent of identifiable effects that may be expected from varying concentrations of the pollutants in ambient air. Along with these criteria, information on air pollution control techniques or methods must be issued, including data on alternate fuels and processes that will result in elimination or significant reduction of the pollutant emissions.

Preparation of the criteria and scientific summary documents that serve as the legally defensible basis for the development of control stategies and the promulgation of ambient air quality standards is the responsibility of the Special Studies Staff.

A major program in CPL is the development of analytical methods and instruments to be used in health and welfare studies to aid in the evaluation or revision of air quality criteria. Also, considerable effort is going into the development of measurement technology for pollutants that may be considered candidates for air quality criteria, e.g., fine particles.

In support of this Section, CSL is evaluating new and existing stationary source control technology procedures on a continuing basis.

QAEML maintains the capability to evaluate methodologies and undertake surveys to obtain scientific information needed by the developers of the criteria documents.

SECTION 109: "NATIONAL AMBIENT AIR QUALITY STANDARDS"

For each pollutant for which an air quality criteria document has been issued, Section 109 of the Act requires that national primary and secondary ambient air quality standards be set. Primary standards concern the minimum level of air quality necessary to prevent adverse health effects; secondary standards are aimed at the prevention of adverse effects on "welfare"; e.g., plants, animals, materials, and climate.

Considerable effort in support of the standards is being made in CPL, particularly to further define the atmospheric relationships involving hydrocarbons and oxidants. Development of continuous measurement instrumentation for nitrogen dioxide (one of the pollutants for which standards have been set) and the evaluation of the reference method for measurement have been accomplished.

SECTION 110: "IMPLEMENTATION PLANS"

In accordance with a prescribed time schedule, Section 110 requires each state to prepare and submit to EPA a plan that provides for the implementation, maintenance, and enforcement of the primary and secondary ambient air standards promulgated in accordance with Section 109. In turn, EPA must make a thorough examination and evaluation of the plan's adequacy in technical concept and allocated resources. If a state fails to submit such a plan within the prescribed time, or if the plan is judged to be not in accordance with the requirements of this Section, then EPA must prescribe (or revise) a plan that meets the requirements. Section 110 also includes the steps and procedures for notices, hearings, or court actions that must or may be utilized in arriving at the objectives sought.

CPL is involved here to support development of chemical and physical air pollution models for reactive pollutants for use in implementation plans, including site criteria for large area sources.

CLS's role is primarily in providing expert testimony relating to the availability of air pollution control technology that could be incorporated in the implementation plans as they relate to the abatement of pollutants from specific sources.

ML provides direct assistance in the evaluation of the meteorological (i.e., transport and dispersion) portions of implementation plans.

QAEML activities support this Section by the evaluation and standardization of methods of measurement for the pollutants for which standards have been set, and by the development and dissemination of quality control procedures for the standardized methods.

SECTION 111: "STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES"

The emission of pollutants from new stationary sources must be regulated under Section 111 of the Act. Categories of such sources are to be established, and uniform national standards that would require application of the best available control technology, considering the cost, for air pollution prevention must be set. EPA must also determine the procedure that the states are to follow in setting emission standards for existing stationary sources.

Extensive support is provided by CPL in verifying and improving the reference methods of emission measurements and in developing performance criteria for the determination of compliance with the new source performance standards.

CSL evaluates the state-of-the-art air pollution control technology for various stationary sources and, based on projected future control needs, develops new control technology.

QAEML provides support here in a manner analogous to that for Section 110, again by the evaluation and standardization of measurement methods and by the development and dissemination of quality control procedures for the standardized methods.

SECTION 112: "NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS"

Section 112 gives EPA the authority to set nation emission standards for hazardous air pollutants, defined as materials discharged into the atmosphere that have a proven relationship with increased mortality rates, or with incapacitating or serious illness.

CPL is responsible for developing the analytical methodology for the national emission standards for hazardous materials. Improved sampling and analysis methods are under development for a number of substances including asbestos, mercury, and polycyclic organic matter.

The identification of all air pollutants from stationary sources is included in the programs of CSL. As the need for control is indicated, the best technological possibilities and the most cost-effective approaches are sought through related research programs.

Again, QAEML support is in terms of measurement methods standardization and quality control procedures. Technical assistance to other EPA units is also rendered to obtain data to assist in the determination of what constitutes a hazardous pollutant.

SECTION 113: "FEDERAL ENFORCEMENT"

The legal actions that EPA must take in the event that violations of an implementation plan are encountered are contained in Section 113. This Section also cites penalties to be assessed for non-compliance with the Administrator's orders.

QAEML maintains a limited rapid-response capability to assist in the collection of data for purposes of Federal enforcement.

SECTION 202: "ESTABLISHMENT OF STANDARDS"

In accordance with the provisions of Section 202, EPA must establish standards of emission for any pollutant from new motor vehicles that is likely to endanger public health or welfare. Section 202 also delineates a time schedule for achieving a large (90 percent) reduction in carbon monoxide and hydrocarbons; additionally, the Section outlines a certification plan for ensuring compliance with the standards by the manufacturers.

CPL provides support in development of emission protocols for fuel additive effects and in characterization of emissions from vehicles either equipped with control devices or utilizing alternate power systems.

SECTION 211: "REGULATION OF FUELS"

Section 211 stipulates that no fuel or fuel additive may be offered for sale until the manufacturer has notified EPA of the product's chemical composition and EPA registers the product. If the fuel or additive endangers public health or interferes with the performance of anti-pollution devices, its use may be restricted or banned. EPA may require tests by the manufacturer to determine such effects.

The fuel and fuel additive registration program is one of the areas of responsibility of the Special Studies Staff. This program involves information retrieval activities in addition to the conduct of research programs to develop protocols that will allow the valid assessment of the effect of fuel components on emission products.

CPL develops emission protocols for fuel additive effects and characterizes the emissions from vehicles equipped with control devices and advanced alternate power systems.

The support of this Section by QAEML is in the development and evaluation of methods of analysis and in the collection and analysis of fuel samples.

SECTION 303: "EMERGENCY POWERS"

Section 303 provides EPA with the authority to act immediately to restrain the emission of pollutants presenting an imminent and substantial danger to the health of persons when appropriate state or local authorities have not acted to abate such sources.

ML provides direct meteorological support for the assessment of weather factors and consequences in actual or potential emergency or accidental air pollution episodes.

SECTION 312: "COMPREHENSIVE ECONOMIC COST STUDIES"

Included in Section 312 is the requirement for EPA to make a comprehensive study of the economic impact of air quality standards as well as an analysis of the national requirements for, and the cost of, controlling emissions to attain those standards.

In this connection, CSL undertakes research and demonstration projects leading to the development of comprehensive data relating to the cost of various air pollution control techniques.

SECTION 313: "ADDITIONAL REPORTS TO CONGRESS"

The Administrator is required to submit annual reports to Congress giving the progress made in implementing the purpose and intent of the Clean Air Act (and amendments). Included must be statements of the (1) status of enforcement actions, (2) progress on control techniques, and (3) standards set or under consideration.

The Special Studies Staff has a major responsibility in the preparation of such reports to Congress and in the identification of problems and additional research efforts that should be brought to the attention of that body.

CPL provides input to the progress reports to Congress on air quality and emission instrumentation and on emission standards for moving vehicles.

ML contributes to these reports by interpreting the effects of weather and climatic factors on existing or proposed air pollution control strategies to ensure that the effects of abatement actions can be isolated from natural variations.

Air quality and emissions data, as well as measurement methods developments, by QAEML are often included in the reports to Congress.

Public Health Service Act

SECTION 241: "RESEARCH AND INVESTIGATIONS"

Section 241 of the Public Health Service Act authorizes research, investigations, experiments, demonstrations, and studies relating to the causes, diagnosis, treatment, control, and prevention of physical and mental diseases and impairments of man. Under this broad charge, EPA has the responsibility to provide Federal guidance on both ionizing and non-ionizing radiation problems affecting health. This responsibility includes the authority to establish environmental standards for safe levels of radioactive materials.

The Experimental Biology Laboratory conducts an extensive program on the known and potential health effects of electromagnetic non-ionizing radiation and ionizing radiation; studies involving the latter are centered about the potential health effects of tritium and krypton-85, both of which are major potential effluents from nuclear fuel reprocessing plants.

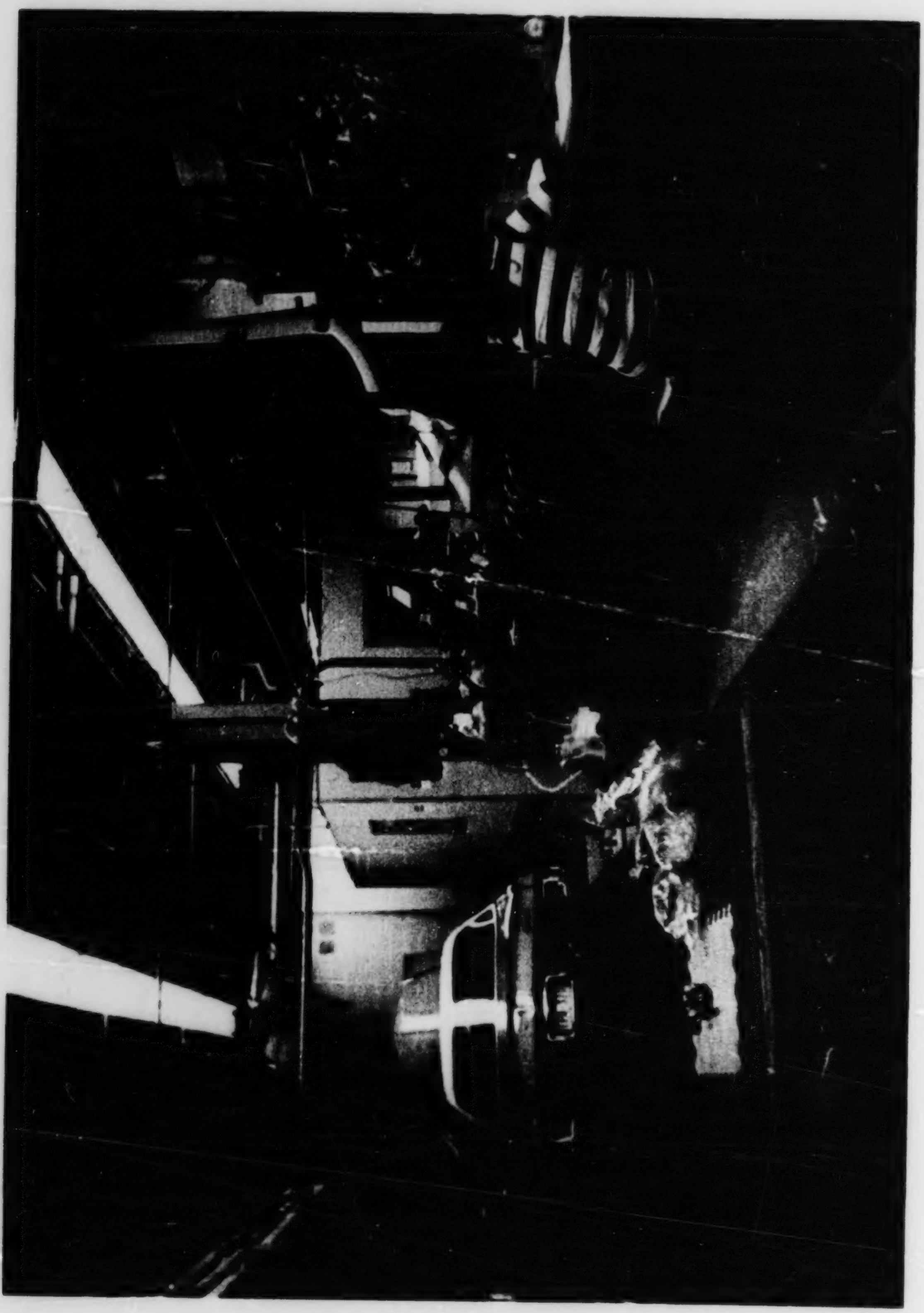
Epidemiologic studies on the effects of exposures from radioactive materials in Japan are under the jurisdiction of HSL.

FDCA and FIFRA

Provisions of the Federal Food, Drug, and Cosmetic Act and the Federal Insecticide, Fungicide, and Rodenticide Act, taken together, seek to protect the safety of the nation's food supply by preventing contamination that might arise through the use of chemical controls to protect crops and livestock from pests and diseases. These provisions require the registration (with EPA) of all such "poisons" as well as the filing of all test results and claims made for them. Also required by these Acts is the establishment of tolerances for pesticides in or on both human and animal food; this responsibility has been delegated to EPA. This provision means that "registration for use" of a pesticide that would leave a residue on a food or feed crop is granted only when a tolerance established by EPA has been satisfied. Interstate shipment of non-registered products is prohibited.

The entire resources of the Pesticides and Toxic Substances Effects Laboratory (PTSEL) are devoted to support of the responsibilities delegated to EPA to carry out provisions of these Acts. The resources are devoted primarily to research activities to support registration decisions and to determine and analyze levels of pesticide residues in or on agricultural products. In particular, data from acute, subacute, and chronic studies of laboratory animals and exposed human subjects are used to augment basic knowledge for continued registration of toxic substances for use in the United States.

SPECIAL FEATURES



SPECIAL FEATURES

EACH YEAR MANY NERC-RTP PERSONNEL and programs reflect, in varying degrees, significant areas of effort relating to EPA's overall goal of reclaiming the purity of this Nation's environment. This portion of the Report focuses on three programs that are of significance because of their near-universal impact: the reduction of automotive emissions through the use of oxidation catalysts; the interface between energy and the environment, spotlighted by the recent fuel shortage; and the efforts to abate effects of pesticides on human health and the environment.

Automotive Oxidation Catalysts

The 1970 Clean Air Act Amendments require that by 1976 the emissions of carbon monoxide, unburned hydrocarbons, and oxides of nitrogen be reduced to 10 percent of the rate of emissions from 1970 and 1971 model year cars. EPA published new motor vehicle emission standards for these regulated pollutants based upon the legislative mandate contained in Section 202 of these Amendments. Although the regulations require the achievement of specific emission levels for these pollutants, they do not require the automotive industry to employ specific technology to do so. The industry has chosen the oxidation catalyst to achieve the standards for 1975 model year vehicles.

NERC-RTP has conducted its Fuel and Fuel Additive Registration program since FY 1971. This program has been specifically directed toward provisions of Clean Air Act Section 211, providing for the registration and prohibition or control of fuels, fuel components, or fuel additives that are shown to have adverse effects on automotive emissions, performance of emissions control devices, or public health or welfare. The major focus of both this program and the Mobile Source Emissions Measurement program (conducted by NERC-RTP's Chemistry and Physics Laboratory) has been to identify not only the effects of fuels, fuel additives, and control devices on the emissions of regulated automotive pollutants (carbon monoxide, hydrocarbons, and oxides of nitrogen), but the effect on non-regulated emission products such as particulates, trace metals, sulfur compounds, polynuclear aromatic hydrocarbons, aldehydes, phenols, and the many other organic compounds present in automotive exhaust gases.

Early in 1973 it was noted that, when oxidation catalysts were used, a substantial increase in total particulate emissions resulted when compared to similar vehicles using the required non-leaded fuel

Emission characterization and emission measurement methodology work is performed at the Chemistry and Physics Laboratory's mobile source facility. Such work is integral to the catalyst program and other automotive pollutant research efforts.

but without the oxidation catalyst present to reduce regulated emission levels. It was determined that this increased particulate emission product consisted of sulfuric acid aerosols. Center research activities were quickly shifted in both the in-house and contract programs to investigate this "new" emission product resulting from the application of the unique emission control device—the oxidation catalyst.

The investigations sought answers to the following key questions:

- Are sulfuric acid aerosol emissions unique to catalyst-equipped vehicles?
- What other unique products, if any, are emitted from oxidation catalysts?
- How much sulfuric acid aerosol is emitted?
- What amount of sulfuric acid aerosol would the general public and the driving public be exposed to as a result of such emissions?
- Would these incremental sulfuric acid exposures be sufficient to pose a public health threat?
- How can sulfuric acid emissions be controlled?

It was determined that sulfuric acid aerosols are indeed emitted from oxidation-catalyst-equipped vehicles and that current, non-catalyst-equipped vehicles emit little, if any, sulfuric acid. Preliminary studies indicated that low levels of platinum and alumina, the active ingredient of the catalyst and its support material, respectively, may also be emitted from such catalysts. It was judged that approximately 0.05 gram of sulfuric acid is emitted per vehicle mile from catalyst-equipped vehicles. These data were generally confirmed by preliminary reports from automotive and petroleum industry research studies that were examining the problem also.

NERC-RTP's Meteorology Laboratory conducted studies to provide estimates of exposure levels to sulfuric acid on and near major highways. These estimates, based on the assumed emission factor for sulfuric acid of 0.05 gram per mile, were used to calculate acid concentrations that would result under various meteorological conditions and under various assumptions as to the number of motor vehicle model years equipped with such catalysts.

Using the estimated incremental exposures calculated by the Meteorology Laboratory, the Human Studies Laboratory provided information based upon its extensive epidemiological studies in the CHESS program as to the potential public health risk of various exposure levels to sulfuric acid and particulate sulfates. It was reported that the localized levels of sulfuric acid aerosols emitted from catalyst-equipped vehicles, after two model years were so equipped, would exceed the threshold adverse health effects levels on several days per year on or near the country's major expressways.

It was determined, by both EPA and industry studies, that the emission levels of sulfuric acid from oxidation-catalyst-equipped vehicles increase with increasing amounts of sulfur in the gasoline. One obvious control option, then, would be desulfurization of gasoline. The Control Systems Laboratory instituted a contract late in 1973 to examine the technical feasibility, cost, and impact of gasoline desulfurization. Preliminary findings indicate that desulfurization of gasoline is technically feasible. The oil refineries, however, would require 4 to 6 years to install the necessary equipment. It is estimated that the total cost to the refining industry would be between $2 and 3 billion depending on the level of sulfur reduction required and on the number and sizes of the refineries involved. The estimated cost to the consumer would be between 1 and 2 cents per gallon.

The problem relative to the emission of catalyst materials themselves was far more complex. Although the emission levels of platinum and palladium (the catalyst active ingredients) were extremely low, it was quickly determined that these metals are essentially not present in the public environment today. Thus, the use of catalysts might result in the introduction of "new" pollutants into the ecosystem. An extensive search of the available literature by the Experimental Biology Laboratory and the Human Studies Laboratory indicated that extremely little work has been reported on the toxicology and/or human effects from exposure to these metals. The information available is based upon industrial exposures in the few processing plants that exist, and these studies suggest that noble metals probably are allergens. Adverse allergenic reactions were reported at very low exposure levels. In addition, a preliminary study suggested that these metals may methylate in the water ecosystem in much the same fashion as mercury.

These findings indicated a need for substantially more information on the potential of noble metals to adversely affect public health. Accordingly, extensive toxicological, biological, and physcological studies were funded both in-house and under contract by the Human Studies Laboratory and the Experimental Biology Laboratory in Fiscal Year 1974.

The concerns voiced by NERC-RTP regarding the potential adverse effects associated with the use of oxidation catalysts resulted in an extensive Agency review of the problem and, finally, in hearings conducted by the Senate Public Works Committee on November 5 and 6, 1973.

The issues involved were indeed complex. The use of oxidation catalysts offered, on one hand, a very definite benefit to public health through the reduction of carbon monoxide, hydrocarbons, and organic emissions. Yet, to what extent was the benefit threatened by the potential adverse effect associated with exposure of the public to sulfuric acid emissions and/or noble metals?

Particulate sulfate compounds, of which sulfuric acid is one, are currently present in ambient air. In fact, many urban areas have levels that exceed the health effects threshold now on many days of the year. Sulfur in gasoline is emitted from our current vehicle population as sulfur dioxide, which disperses and reacts in the atmosphere to form sulfates. The automotive-generated sulfur dioxide amounts to about 1 percent of the man-made sulfur dioxide emissions on a national basis. The automotive catalyst, therefore, causes an immediate conversion of some of this gas to sulfate, resulting in increased concentrations on and near areas of high vehicle density. The public health problem, then, is one of adding an increased localized concentration of sulfate to existing ambient sulfate concentrations.

In testimony before the Senate in November 1973, the Administrator of EPA voiced his decision regarding the catalyst issue:

- EPA will permit the use of catalysts on 1975 model year vehicles.
- EPA will conduct an expanded and accelerated research and monitoring program to ascertain the validity of projected health and early emissions data.
- EPA will conduct an appropriate program to consider control options if the predictions are borne out.

The initial part of the expanded monitoring program was begun in the spring of 1974 by NERC-RTP's Quality Assurance and Environmental Monitoring Laboratory. This program is directed toward the gathering of base-line information at selected highway sites in Southern California concerning the amount, types, and concentration profiles of sulfur emissions from the current vehicle population. The research and monitoring program will greatly expand in Fiscal Year 1975 and will include most NERC-RTP laboratories in a program directed by the Special Studies Staff within the Fuel and Fuel Additive Registration program.

The objective of this program is to gather the necessary information to ensure that the use of oxidation catalysts on future passenger vehicles results in a net benefit to public health. The results from this program are distributed to and used by other Agency offices, the Administrator and his staff, and the Congress of the United States.

Energy and the Environment

THE PROBLEM

The fundamental energy problem facing the United States is the growing gap between energy consumption and domestic energy production. In 1950, the United States was self sufficient in energy production; in 1973, 76 × 10^{15} Btu of energy was consumed, of which 62 × 10^{15} Btu was produced domestically. (The use of imported oil represented the major difference between production and consumption.) Today 15 percent of our total energy needs, and 35 percent of our oil, is imported. Energy consumption in the United States is increasing at an annual rate of almost 4.5 percent; whereas, the rate of domestic energy production has been at a standstill since 1970.

The oil embargo directed by Middle Eastern oil-producing countries forced recognition of the seriousness of the energy gap before American dependence on imported oil presented an unmanageable problem. There is still time, therefore, to evolve a national energy program of conservation and development that will make us independent of foreign supply. Although environmental regulations may have made the energy problem more severe or precipitated it somewhat earlier, the basic problem is that the U.S. cannot sustain the rate of increase in energy consumption experienced during the last few years.

Energy production and use and the environment are inextricably intertwined: the major source of air pollution is fuel combustion either in furnaces or in internal combustion engines. Thus, the control of emissions both from these sources and from the related extraction, processing, and handling of fuels is the major means of controlling air pollution.

Pollution costs are difficult to measure in monetary terms. EPA estimated that air pollution damage in the U.S. in 1968 amounted to:

$6.1 billion for damage to human health.
$5.2 billion for residential property damage.
$4.7 billion for damage to inert materials.
$0.1 billion for vegetation damage.

Pollution control activities since 1968 have resulted in a reduction in pollution damage, however.

Another potential long-range problem is the possibility of changes in climate as carbon dioxide and fine particulates build up in the air. Some scientists believe this problem already exists to some degree. Dr. Reid Bryson, director of the University of

Wisconsin's Institute of Environmental Studies, states: "Up to 50 years ago man's influence on the climate was negligible. Then it started to increase. Over the past century it has worked out to 16 to 20 percent compared with natural influences. But this means it has been very high in recent years, because it was so low earlier. Today it is quite comparable to natural causes."

A key to solving the energy problem may be found by analyzing the nature of energy consumption. Approximately 50 percent of the energy produced in the United States is wasted. This makes a strong case for conservation as the prime element in energy management. Because air pollution is directly proportional to the amount and type of fuel consumed, energy conservation also promotes environmental goals. For example, solar energy is "free" and environmentally clean; heat pumps are both efficient and non-polluting (especially from an area source standpoint). Although add-on pollution control devices usually increase energy consumption by 5 to 10 percent, on balance there is more commonality than disparity in energy and environmental goals.

Table 3 shows that substantial energy savings can be realized in industrial, commercial, residential, and transportation applications if new technologies are employed. The achievement of energy self sufficiency will not be easy, but zero energy growth can be reached while still enjoying the "good life." If Americans discipline themselves to some changes in their way of life, and demand a sound national energy policy, the problems can be solved.

EPA'S ROLE

EPA's research and development role in the national energy/environmental program is not completely defined, nor will it be until the proposed Energy Research and Development Agency structure is clearly established by the Congress. It is generally agreed, however, that effects research (health and welfare) and the assessment of the pollution characteristics of the various energy extraction, transportation, preparation, and transformation technologies are part of EPA's charter.

Table 3. POSSIBLE ENERGY SAVINGS THROUGH USE OF CONSERVATION TECHNOLOGY AVAILABLE IN 1985 AND 2000[a]

Sector	% of total demand	1985	Savings, %	2000	Savings, %
		Method		Method	
Residential-commercial	35	Heat pumps, total energy system, solar heating and cooling systems, better insulation, tighter building construction, more efficient furnaces and air conditioners	6	Catalytic combustion processes, advanced fuel conversion systems, advanced total energy systems	45
Transportation	25	Cars with fuel economy of 25 mi/gal, improved aircraft load factor and efficiency, short-haul air freight shifted to rail, truck freight shifted to rail	20	Electric vehicles (fuel cell and battery), improved mass transit systems	50
Industrial	40	Improved maintenance (e.g. steam leaks fixed), energy-using systems turned off when not needed, heat loss eliminated from buildings, more efficient electric/steam systems	25	Full use of total energy systems (combined steam/electric), heat pumps, solar heating and cooling systems	50
Total	100		17		48

[a] Based on historical growth: 1972–100 percent, 1985–160 percent, 2000–255 percent.

There is some question whether EPA will retain its capability to develop pollution control technology for energy processes—a capability that is the key to environmental protection. Energy developers will probably be interested mainly in developing the most efficient energy processes with concerns for adequate environmental control technology of secondary importance. EPA must have the authority to develop a better pollution control system in those cases in which the pollution control measures taken by the energy developer are considered inadequate by EPA.

The problem of energy and the environment becomes even more acute when it is realized that the main energy utilization systems for the forseeable future are to be developed within the next 5 years by a massive, government-financed research and development program. Within this brief period of time, it will be impossible to quantify adequately the pollutants of concern and to assess their associated health effects. It will thus be impossible to accurately define the pollutant control levels required. Furthermore, once the energy technologies are in place it will be difficult and expensive to retrofit them with improved pollution control equipment: retrofit may cost three times as much as that of installation of original equipment. The best means of protecting the public's health is to have an active pollution control program to develop new and improved control methods for these energy systems that will provide the minimum pollution levels that can be achieved technically at an acceptable cost.

PRESENT AND FUTURE PROGRAMS AT NERC-RTP

Of primary concern to EPA is the protection of the health and welfare of people. Therefore, a major portion of NERC-RTP's program is directed toward minimizing the effects of air pollution on health. Two broad areas of research are being given special emphasis: studies of the human response to exposure to specific pollutants (singly or in combination) that are likely to be emitted to the atmosphere in larger quantities because of the fuels used and programs for the development of methods for controlling emissions from both stationary and mobile power generating facilities.

Within NERC-RTP, the Human Studies Laboratory (HSL) and the Experimental Biology Laboratory (EBL) have primary responsibility for studying the health impact of policy decisions concerned with energy production. These Laboratories conduct a comprehensive program of toxicological, clinical, and epidemiological studies to assess the effects of air pollutant exposure on human health. The Control Systems Laboratory (CSL) has the main responsibility within NERC-RTP for developing technology to control air pollution.

It is acknowledged that the greatest increases in human health risks will be associated with increased pollution resulting from the greater use of coal to fuel power-generating facilities. The pollutants of primary concern are sulfur oxides and trace substances that contaminate the coal. The sulfur oxides are emitted as gases as the coal is burned, but in the atmosphere they are transformed at a regular rate to sulfuric acid mist and particulate sulfates. HSL studies, therefore, attempt to develop information relative to adverse health effects associated with exposure to ambient concentration of total suspended particulates. (Fine sulfates and nitrates are particularly suspect.)

EBL has initiated studies in laboratory animals to determine the relative toxicity of various metallic sulfates. HSL, as part of its responsibility, conducts a continuing program of studies to determine the adequacy of all established ambient air quality standards. During the fiscal year, more than $1 million was spent for this purpose on studies of the effects of SO_x and particulate matter on human health. In addition, $3.4 million was allocated to HSL from the energy program to study the health impact of decisions concerning the alternative strategies for power production. These funds were used to support contract studies of the effects of sulfates, nitrates, or total respirable particulates on human health. The funds also supported a $1 million interagency agreement with the National Institute of Environmental Health Sciences to provide additional information (from a non-EPA source) on the effects of energy-related pollutants. These separately collected data sets are expected to verify EPA studies and provide greater overall support to policy decisions made within the Agency. One of the major objectives of the program in Fiscal Year 1975 will be the development of more precise measurements of human exposure in ambient situations to permit the establishment of relationships with air monitoring data as well as closer coordination between the field epidemiological efforts and the carefully controlled clinical laboratory studies. Other studies will expand the effort to obtain data on human response to specific particulates both in a clinical setting and in ambient air situations.

The financial support given to research into issues raised by the energy problem will first of all provide for a more rapid development of health effects data. It is likely, however, that the financial support will also intensify the energy problems because additional study is expected to show that relaxation of efforts to reduce air pollution levels may well result in significant increases in the incidence of adverse health effects—effects that can be measured by increased mortality rates, increased prevalence of chronic respiratory illness, poorer pulmonary function, and increased aggravation of symptoms in asthmatics or individuals with cardiac illness. The trade-off of increased health risk to meet ever-increasing energy demands may well be a point on which individuals with diverse interests will find it difficult to agree.

For the long term, however, the increased effort at this time will provide a stronger basis on which decisions can be made that may change our attitudes about energy conservation, the degree of pollution control required, and (to some extent) our life style. This increased effort will ultimately assure a healthier environment for all of us.

The Control Systems Laboratory program includes several projects that will have a major impact upon the availability of clean energy. The projects under development, although generally not specifically related to the energy production process, are focused upon the control of emissions of harmful pollutants. Because of simularities in control requirements and processes, methods developed for the control of industrial emissions may be applicable to energy-related processes; for example, research and development on scrubbers would be applicable to electric utilities as well as to chemical plants, pulp and paper plants, oil refineries, and steel mills.

Perhaps EPA's most significant contribution to clean energy production is flue gas cleaning: about 80 percent of CSL's expenditures to date have been concentrated in this area. CSL's early efforts helped develop the limestone scrubbing process, and its present efforts are helping to lower costs and increase effectiveness and reliability. CSL is participating in the development of many other advanced flue gas cleaning prototype demonstrations including magnesium oxide scrubbing, catalytic oxidation, sodium ion scrubbing with thermal regeneration, and sodium hydroxide scrubbing with electrolytic regeneration. Clean fuels and flue gas cleaning are the only techniques expected to be applied to a large extent in controlling sulfur oxides emissions during the next 10 years. With the probable shortage of clean fuels (clean coal will amount to about 20 percent of the demand), flue gas cleaning will apparently have to be applied widely.

With respect to energy production processes, CSL is currently developing technology for the control of sulfur oxide, fine particulate, and nitrogen oxide that will be applicable to both combustion and non-combustion sources. Projects to assess and ultimately control the environmental impact of new energy processes have already begun. Finally, activities have recently been initiated for the characterization of potentially hazardous pollutants from combustion and other sources. This program will lead to new control technology development as additional source and pollutant information becomes available.

As part of the concerted Federal effort to solve the energy crisis, EPA's Office of Research and Development—with substantial support from NERC-RTP's Control Systems Laboratory—participated fully in the Energy Research and Development Program Task Force effort that produced *A Report to Richard M. Nixon, President of the United States—The Nation's Energy Future*. This interagency effort and subsequent evaluation, planning, and coordination with the Office of Management and Budget resulted in a $186 million supplement to EPA in Fiscal Year 1975 to address the important areas of environmental assessment and control technology development.

As part of an effort to develop and coordinate an EPA-managed environmental research and development program to interface with the Federal energy program, EPA's Office of Research and Development, with substantial support from NERC-RTP, undertook a matrix planning exercise to prepare specific program objectives. The four major energy research and development areas covered were fossil fuel combustion and conversion, fossil fuel extraction, conservation, and nuclear and advanced systems. To define the environmental impact of energy technologies in these four areas, EPA's contribution to the complex research and development matrix included environmental information systems development, measurement and monitoring efforts, health efforts research, ecological processes and effects research, social effects and policy implementation studies, air pollution control, industrial water control, and non-point source control.

EPA's overall aim is to provide increasingly accurate and comprehensive information to permit environmental impact assessment and environmental policy formulation relative to a specific energy technology. Before actual commercial application of energy technology, it is EPA's aim to have the national environmental impact defined and the siting criteria developed to the point where they can be utilized to provide a basis for evaluating the environmental suitability of sites throughout the United States. This definition will allow comparison of alternate energy technologies on the basis of their overall environmental impact.

Substitute Pesticide Chemicals

NERC-RTP's Pesticides and Toxic Substances Effects Laboratory (PTSEL) is involved in studies in two major areas relating to substitute chemicals. The first area relates specifically to pesticides and pesticides substitutes; the other relates more generally to toxic substances.

PESTICIDE CHEMICALS PROGRAM

The 1972 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended, places an increased emphasis on EPA to regulate pesticide chemicals through full consideration of the consequences on human health and on the environment from the use of pest control products. The determination to cancel or suspend a product registration is made after exhaustive review of the pesticide and of the potential harm of pesticide materials designated as potential substitutes. Recognizing the enormity of the program to evaluate the hazard of a pesticide and to assess the acceptability of a substitute if removal is indicated, a $5 million, 50-position program to study pesticides and feasible substitute chemicals was included as part of the proposed Agricultural, Environmental, and Consumer Protection Appropriation Bill for 1974.

Three integrated strategies were considered necessary to implement this program: (1) scientific review of known registered pesticides, (2) establishment of a cooperative liaison with industrial research and development to expedite the development of pesticides as substitutes for those removed from use, and (3) generation of data relative to the problem of a pesticides hazard as a function of toxicity, persistence, and potential for eliciting an undesirable response. The review processes will define data gaps in background information that can be filled by initiating research, monitoring, and testing programs.

PTSEL maintains several broad areas of responsibility, including inhalation toxicology; toxicity screening and testing; chemical determination of toxicologically significant impurities in commercial preparations of pesticides; and multiresidue methods for detection of pesticides. Primary programs are being designed to satisfy the questions arising in the review process of pesticides and to allow a rapid response to all inquiries and thus permit the review and administrative actions to be completed in a minimum of time. It is anticipated that this program will allow EPA to expeditiously remove materials from the market that are designated as harmful to humans or the environment, and will further allow EPA to rationally assess materials designated as substitute chemicals.

TOXIC SUBSTANCES EFFECTS PROGRAM

PTSEL has an expanding role in assessing the toxicity of synthetic organic compounds, metals, and metallic compounds and in developing sensitive analytical methods for measuring toxic substances in the environment. Currently, approximately two million chemical compounds are known; several thousand new compounds are synthesized annually. Each year, several hundred of these new chemicals are introduced into commercial use even though their potential impact on health and the environment in most cases is not known.

The pending Toxic Substances Control Act (TSCA) is an important legislative approach to control the introduction of toxic substances into the environment. Rather than focusing on pollutants in the media (e.g., air and water), the TSCA relies on understanding the flow of potentially toxic substances throughout the entire range of activity—from extraction (or synthesis), through production and consumer use, to disposal. Of particular concern are the potentially deleterious effects on health resulting from long-term exposures to low levels of these chemicals, alone or in combination.

PTSEL projects over the past year have supported the research needs of EPA's Office of Toxic Substances. Animal model studies were completed on the effects of polychlorinated biphenyl compounds, hexachlorobenzene, cadmium, and TCDD (2, 3, 7, 8-tetrachlorodibenzo-p-dioxin). Preparing for public hearings, PTSEL carried out over 300 ultra-trace (ppb) determinations of TCDD in a variety of environmental samples (including human adipose tissue and agricultural products) utilizing an improved sample-preparation procedure followed by high-resolution mass-spectrometry analysis.

Future research on toxic substances will include development of rapid toxicological screening methods; determination of toxic impurities in commercial chemicals; development of a tissue bank to assess the accumulation of toxic substances in human tissue over long time periods; and the development of chemical analytical methods for the determination of trace levels of metals, metallic compounds, and synthetic organic compounds. PTSEL is also planning to develop a rapid-respones capability to address environmental crisis situations that will involve short-term sample collection, chemical analysis, and toxicological assessment.

RESEARCH ACTIVITIES

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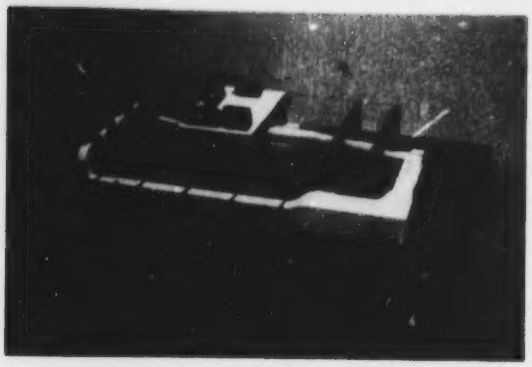
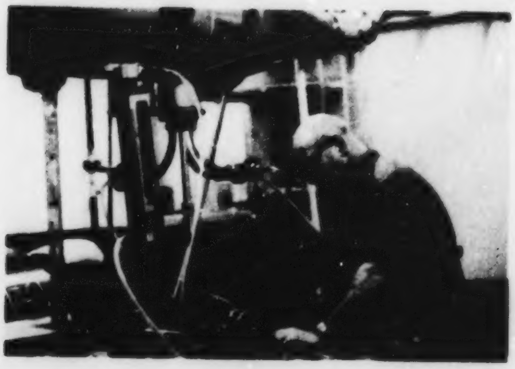
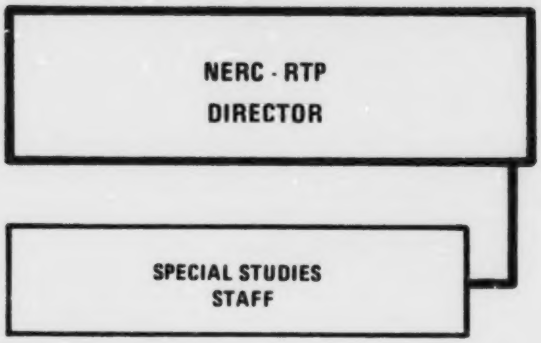




Special
Studies
Staff

Special Studies Staff



Scientific and Technical Assessment Reports, which serve as a basis for determining pollutant control strategies in EPA, are produced by the Special Studies Staff.

OVERVIEW OF SSS MISSION

The Special Studies Staff, located in the Office of the NERC-RTP Director, is engaged in activities in three major technical areas: (1) preparation of air quality criteria documents and scientific and technical assessment reports involving pollutant characterization, (2) fuel and fuel additive registration and vehicular emission research, and (3) participation in or coordination of NERC-RTP international activities. In addition, the Staff carries out various *ad hoc*, short-term projects.

LEGISLATIVE MANDATE

The legislative mandate upon which the Special Studies Staff's programs are based and the various sections of the Clean Air Act requiring Staff support are shown below with a brief description of the types of activities engaged in to support the mandate and the Act.

> "RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES
>
> "Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution . . . .
>
> "(b) In carrying out the provisions of the preceding subsection the Administrator is authorized to—
>
> "(1) collect and make available . . . the results of and other information, including appropriate recommendations by him in connection therewith, pertaining to such research and other activities;. . .
>
> "(7) collect and disseminate . . . basic data on chemical, physical, and biological effects of varying air quality and other information pertaining to air pollution and the prevention thereof;. . .
>
> "(c) In carrying out the provisions of subsection (a) of this section the Administrator shall conduct research on, and survey the results of other scientific studies on, the harmful effects on the health or welfare of persons by the various known air pollutants . . .
>
> "AIR QUALITY CRITERIA AND CONTROL TECHNIQUES
>
> "Sec. 108. (a) . . . (2) The Administrator shall issue air quality criteria for an air pollutant . . . Air quality criteria for an air pollutant shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of such pollutant in the ambient air, in varying quantities . . .
>
> "(b) (1) Simultaneously with the issuance of criteria under subsection (a), the Administrator shall. . . issue . . . information on air pollution control techniques . . . Such information shall include such data as are available on available technology and alternative methods of prevention and control of air pollution . . .
>
> "(c) The Administrator shall from time to time review, and, as appropriate, modify, and reissue any criteria or information on control techniques issued pursuant to this section . . .

> "ADDITIONAL REPORTS TO CONGRESS
> **"Sec. 313 . . . the Administrator shall report to the Congress on measures taken toward implementing the purpose and intent of this Act including, but not limited to . . . (2) the development of air quality criteria and recommended emission control requirements . . . (4) the status of State ambient air standards setting, including such plans for implementation and enforcement as have been developed. . ."**

As indicated above, Sections 103, 108, and 313 of the 1970 Clean Air Act Amendments permit EPA's Administrator to require the preparation of scientifically sound assessment or criteria documents to serve as the legally defensible basis for both the development of control strategies and the promulgation of standards. The preparation of criteria documents and scientific and technical assessment reports by this Staff contributes to the requirement of these sections of the Act.

Characterization of pollutants consists of critically reviewing, evaluating, comparing, and interpreting pertinent literature to revise present, or prepare additional, air quality criteria documents and prepare scientific and technical assessment reports that serve as the scientific basis of control strategies and related standards. These documents are also required to identify the need of additional research for producing adequate criteria for issuing or revising standards.

> "REGULATION OF FUELS
> **"Sec. 211. (a) The Administrator may by regulation designate any fuel or fuel additive and . . . no manufacturer or processor of any such fuel or additive may sell, offer for sale, or introduce into commerce such fuel or additive unless the Administrator has registered such fuel or additive in accordance with subsection (b) of this section.**
>
> **"(b) (1) For the purpose of registration of fuels and fuel additives, the Administrator shall require—**
>
> **"(A) the manufacturer of any fuel to notify him as to the commercial identifying name and manufacturer of any additive contained in such fuels;. . .**
>
> **"(B) to furnish . . . such other information as is reasonable and necessary to determine the emissions resulting from the use of the fuel or additive contained in such fuel, the effect of such fuel or additive on the emission control performance of any vehicle or vehicle engine, or the extent to which such emissions affect the public health or welfare . . .**
>
> **"(c) (1) The Administrator may, from time to time on the basis of information obtained under subsection (b) of this section . . . control or prohibit the manufacture, introduction into commerce, offering for sale, or sale of any fuel or fuel additive for use in a motor vehicle or motor vehicle engine . . ."**

Sections 211 (a) and (b) of the 1970 Clean Air Act Amendments permit the Administrator to require the registration of fuels and fuel additives as a prerequisite to sale. These sections also permit the Administrator to require, as a prerequisite to registration, that tests be conducted by the manufacturer to determine the effect of such fuels or fuel additives on emissions (regulated and non-regulated), the performance of emissions control devices, public health, and public welfare. Such tests are to be conducted on the basis of protocols established by the Administrator.

Section 211 (c) provides that any registered fuel or fuel additive may be restricted or prohibited based upon adverse effects observed from such tests or from other such information available to the Administrator.

The Special Studies Staff's fuel and fuel additive program consists of registration and information retrieval activities in addition to conducting research programs to develop protocols that will allow the valid assessment of the effect of fuel components and fuel additives on emission products (both regulated and non-regulated), performance of emission control devices, atmospheric loadings and transformations, and public health and welfare.

By contractual agreement with the World Health Organization (WHO), EPA was established as WHO's International Reference Center for Air Pollution Control (IRCAPC). The responsibility for responding to WHO requests was assigned to NERC-RTP by EPA's Assistant Administrator for Research and Development who is also the Director of WHO-IRCAPC.

The Special Studies Staff's international activities consist of providing direct technical assistance and liaison to international organizations in preparing international environmental pollutant criteria and guidelines as well as coordinating other NERC-RTP involvement with the WHO, Organization for Economic Cooperation and Development (OECD), NATO's Committee for the Concern of Modern Society, Special Foreign Currency Program, World Meteorological Organization (WMO), Economic Commission for Europe, and the Council of European Communities.

Information concerning fiscal and personnel resources, presented in Table 4, includes funds and personnel within the Agency and on contract.

Table 4. SUMMARY OF RESOURCES FOR SPECIAL STUDIES STAFF FOR FISCAL YEAR 1974

Section of Clean Air Act supported	Funds, $\$10^3$	Positions	Approximate percent
103	156	3	15
108	158	3	15
211	718	12	69
313	10	1	1
Totals	1042	19	100

ORGANIZATION

The Special Studies Staff, functioning under the general guidance of a Director, concentrates on two subject areas—Pollutant Characterization and Fuel and Fuel Additive Registration.

To meet its responsibilities in pollutant characterization, fuel and fuel additive registration, and international activities, the Special Studies Staff emphasizes both extramural tasks with supporting in-house activities to obtain basic and background information, and direction and coordination of in-house NERC-RTP task force activities concerning preparation of multidisciplinary and multimedia environmental pollutant scientific and technical assessment reports.

Pollutant Characterization

Personnel involved in Pollutant Characterization produce technical documentation to be used in decision-making regarding pollution control. This group assists international organizations in preparing similar technical documentation. Involvement begins with a search for basic information, and extends through publication of the document. The Staff Director coordinates NERC-RTP's international activities.

Fuel and Fuel Additive Registration

The Fuel and Fuel Additive Registration group is involved in receiving and storing information from manufacturers as required by law and registering their products. Personnel also assist in the development of related regulations and guide research carried out external to the immediate group.

MAJOR PROGRAM AREAS

Pollutant Characterization

The Pollutant Characterization activities of the Special Studies Staff provide documentation critically reviewing, evaluating, comparing, interpreting, and summarizing pertinent literature and reports. This documentation leads to the (1) revision of existing criteria documents or the preparation of additional scientific and technical assessment reports for air quality of currently non-regulated environmental pollutants, (2) identification of the need for additional research required to produce adequate criteria for issuing or revising standards, and (3) preparation of briefing reports that address new areas for environmental concern that are not already part of an integrated program.

Air quality criteria, as defined by the Clean Ai Act, are compilations of the latest available scientific information on the sources, prevalence, and manifestations of recognized air pollutants. Most importantly, these criteria describe the effects that have been associated with, or may be expected from, an air pollutant level in excess of a specific concentration for a specific time period. Such effects generally involve visibility reduction, damage to materials, economic costs, vegetation damage, nuisance aspects, and adverse effects on the health and well-being of humans and animals. Air Quality Criteria serve as the basis for national ambient air quality standards.

The scientific and technical assessment reports serve two very important purposes. They summarize the scientific knowledge base for administrative decisions regarding the need and strategy for control; and they provide important input for research and development program plans. In view of their widespread distribution, these documents also serve as an important communications link with other EPA offices, other agencies, and special-interest groups. In order to serve these purposes, they must be functional documents, clearly and concisely written.

Assessment reports are prepared under the supervision of the Special Studies Staff by task forces made up of staff members from the laboratories of NERC-RTP and from the other NERCs. The reports are based on standard outline to ensure inclusion of available information on the following items:

- Chemical and physical properties.
- Measurement techniques applied to various environmental compartments (e.g., air, water, and soil), sources, and (when pertinent) biological samples.
- Origin and abundance.
- Concentrations in air, water, soil, plants, animals and humans, and microorganisms.
- Transformations and transport.
- Environmental exposure.
- Mechanisms of exposure.
- Physiological response.
- Undersirable effects on humans, animals, vegetation, materials, weather, visibility, climate, and land and water resources.
- Control technology and remedial actions.
- Current research and development activities.

These reports are generally based on review material provided by panels of experts assembled by the National Academy of Sciences (NAS) under contract with the Special Studies Staff, although other organizations have provided similar resources. Supplementary information is used as available and required. When no basic review document is available, the basic literature is searched.

Basic review documents are being prepared by NAS on vapor-phase organic matter, chlorine, selenium, copper, zinc, arsenic, and the platinum-group heavy metals. In keeping with timely review of criteria documents, NAS is preparing reviews on carbon monoxide, photochemical oxidants, nitrogen oxides, and fine particulate matter. NAS recently submitted to the Special Studies Staff reports on nickel, chromium, and vanadium. Task forces are currently preparing reports on vadium, chromium, nickel, and nitrates.

Reports on particulate polynuclear organic matter, sulfates and sulfuric acid aerosols, polychlorinated biphenyls, cadmium, and manganese are now being finalized prior to publication.

The Special Studies Staff completed a review and revision of the vegetation effects chapter of *Air Quality Criteria for Sulfur Oxides* in 1973, requiring EPA review of the secondary standards for sulfur oxides that led to the standards' revision. The Special Studies Staff has also prepared and presented briefings for EPA's Office of Research and Development (ORD) on fine particulate matter and nitrates.

Scientific and technical assessment reports are to be prepared for selenium, chlorine/hydrochloric acid, arsenic, vapor-phase organic matter, copper, zinc, and platinum-group heavy metals. A briefing document on particulates from mobile emissions is also to be prepared. The air quality criteria documents for nitrogen oxides, photochemical oxidants, hydrocarbons, sulfur oxides, particulates, and carbon monoxide are to be updated and/or revised.

Fuel and Fuel Additives Registration

The Fuel and Fuel Additives Registration program, reorganized in Fiscal Year 1974 involves registration, emissions characterization, toxicological testing, human studies, fuel surveillance and analysis, health and welfare effects, and the development of related effects protocols. These subject areas provide a complex, interrelated, multidisciplinary technical program, the objective of which is to ensure the continued protection of the public health and welfare as it relates to the mobile source emissions control program, and the effects that fuels, fuel additives, advanced control devices, and alternate power systems have thereon. The development and review of this integrated program, which is the responsibility of the Special Studies Staff, includes the review, evaluation, and reporting of data collected and proposals for necessary action.

Registration—Additives used in gasoline introduced into interstate commerce must be registered with EPA. At the present time, more than 325 such additives are registered in a number of chemical classifications.

Emission Characterization—Characterization of both regulated and non-regulated exhaust pollutants and the effect of fuel components and fuel additives thereon are essential to provide the preliminary information required to assess potential adverse effects of such fuel components or additives on emissions and emission control device performance. In addition, detailed characterization of exhaust products resulting from combustion of fuels with and without additives and products emanating from catalytic control devices and alternate power systems is essential in order to provide the data necessary to conduct meaningful health effects studies.

A result of this program has been a reassessment of the public health benefit related to the use of oxidation catalysts on mobile sources and the attendant increase in levels of potentially hazardous non-regulated emissions.

The past efforts and future research emphasis related to emission characterization are presented in Table 5.

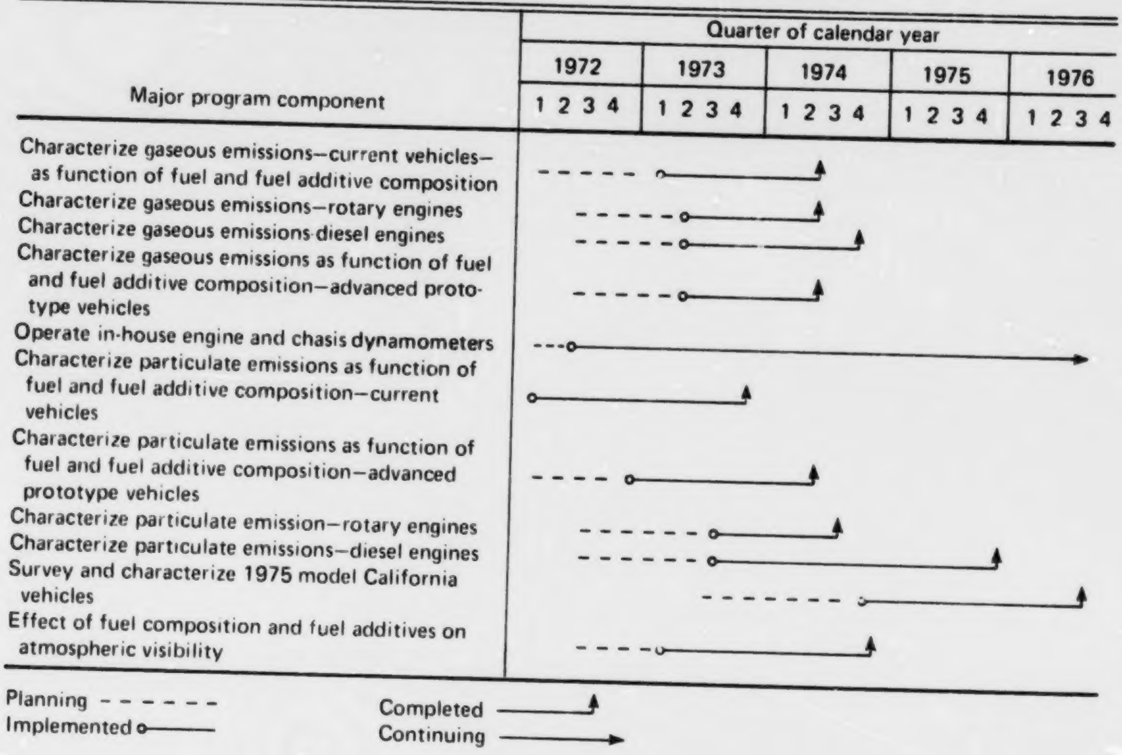
Emissions Effects Protocols—EPA may require that tests be conducted by any fuel or fuel additive manufacturer to ascertain the effects of such fuel or fuel additive on both emissions and control device performance. Such tests are to be based on protocols specified by the Administrator and are largely extensions of the research programs outlined previously under *Emission Characterization.*

The past efforts and future research emphasis related to emissions effects protocols are presented in Table 6.

Surveillance—Collection of commercial fuels, crankcase oils, and diesel fuels, and their subsequent analysis are essential to ensure both the validity of the registration information upon which the research program is based and the dependable performance of consumer-operated advanced control systems that already have been shown to be sensitive to particular fuel and oil components and additives. This activity is just getting under way.

Health Effects Assessment—The Agency is developing the health intelligence necessary to ensure that public health is protected by the mobile source emissions control program. Available serviceable toxicologic models and human exposure study techniques can provide a reasonable data base for decision-making. Although a hierarchical screening system has not been developed, there is no doubt that such a system would be most valuable in obtaining answers

Table 5. EMISSION CHARACTERIZATION MILESTONES


Major program component

Characterize gaseous emissions—current vehicles—as function of fuel and fuel additive composition

Characterize gaseous emissions—rotary engines

Characterize gaseous emissions-diesel engines

Characterize gaseous emissions as function of fuel and fuel additive composition—advanced prototype vehicles

Operate in-house engine and chasis dynamometers

Characterize particulate emissions as function of fuel and fuel additive composition—current vehicles

Characterize particulate emissions as function of fuel and fuel additive composition—advanced prototype vehicles

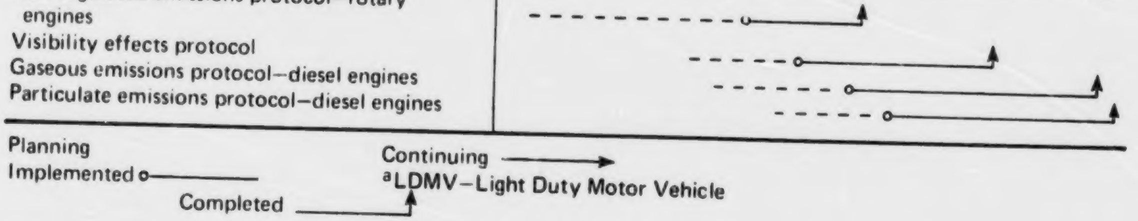
Characterize particulate emission—rotary engines

Characterize particulate emissions—diesel engines

Survey and characterize 1975 model California vehicles

Effect of fuel composition and fuel additives on atmospheric visibility

Table 6. EMISSION EFFECTS PROTOCOL MILESTONES


Major program component

Emission control device performance protocol

Regulated emissions (HC, CO, NO_x) protocol—LDMV[a]

Particulate emissions protocol—LDMV

Non-regulated emissions protocol—rotary engines

Visibility effects protocol

Gaseous emissions protocol—diesel engines

Particulate emissions protocol—diesel engines

[a] LDMV—Light Duty Motor Vehicle

to key health questions more rapidly. The program gives immediate priority to toxicologic assessment (using simple and relatively rapid techniques) of compounds of palladium, platinum, and ruthenium believed most likely to occur in auto emissions, since this information needs to be available before the large-scale introduction of catalytic converters with the potential for introduction of novel pollutants into the environment. The currently funded 3-year program is summarized in Table 7.

International Activities

The Special Studies Staff serves as a focal point for coordinating the international activities of NERC-RTP. In addition, it provides direct assistance concerning criteria and other documentation.

World Health Organization—The WHO has designated EPA/ORD as its International Reference Center for Air Pollution Control. The Assistant Administrator has delegated the responsibility for meeting this obligation to NERC-RTP.

In meeting this obligation, NERC-RTP's Quality Assurance and Environmental Monitoring Laboratory serves as an International Aerometric Data Bank, receiving, processing, analyzing, and publishing data received from international laboratories via WHO. In cooperation with the Organization for Economic Cooperation and Development, QAEML assists and directly participates in the development of WHO standardized measurement methodology for monitoring air pollution.

The Special Studies Staff, at WHO's requests, contributed to WHO air criteria and guideline documents via annotated outlines and draft manuscripts. The staff provided draft annotated outlines for *Air Quality Criteria and Guides for Nitrogen Oxides* and *Guidance Manual for Planning, Implementing and Evaluating Air Pollution Regulations and Control Programs.* Draft documents were also provided representing the U. S. contribution to WHO for environmental health criteria for manganese and polychlorinated biphenyls. Additional documents of this nature are to be provided on a requested basis.

Organization for Economic Cooperation and *Development*—NERC-RTP's Deputy Director is the official U. S. delegate to the OECD Air Management Sector Group. Activities of this group concern air pollution problems that transcend international frontiers, the international interchange of air pollution monitoring and research data, the economics of air pollution control policies and their implications relative to international trade, and needs for additional research and international cooperation to meet these needs.

The Special Studies Staff assisted OECD in 1973 by evaluating WHO's *Air Quality Criteria and Guides for Urban Air Pollutants* and by preparing, with cooperation from OAQPS, a case history on the use of criteria in developing standards for the control of sulfur dioxides in the United States.

NATO's Committee on the Challenges of Modern Society—The NATO Committee on the Challenges of Modern Society (CCMS) conducts eight designated pilot studies, one of which deals with air pollution. The United States is the pilot nation for this study, with the Federal Republic of Germany and Turkey as co-pilot nations. The following four major tasks were concluded in May 1974:

Task I. Assessment of ambient levels of sulfur oxides and particulate pollution and sources for both present conditions and projected growth. (NERC-RTP's Quality Assurance and Environmental Monitoring Laboratory)

Task II. Selection of appropriate mathematical diffusion modeling techniques to relate source emissions to ambient air levels. (NERC-RTP's Meteorology Laboratory)

Task III. Development of air quality criteria documents for sulfur oxides, particulates, carbon monoxide, nitrogen oxides, and photochemical oxidants and related hydrocarbons. (NERC-RTP's Special Studies Staff)

Task IV. Development of control technology documents for pollutants cited above. (NERC-RTP's Control Systems Laboratory)

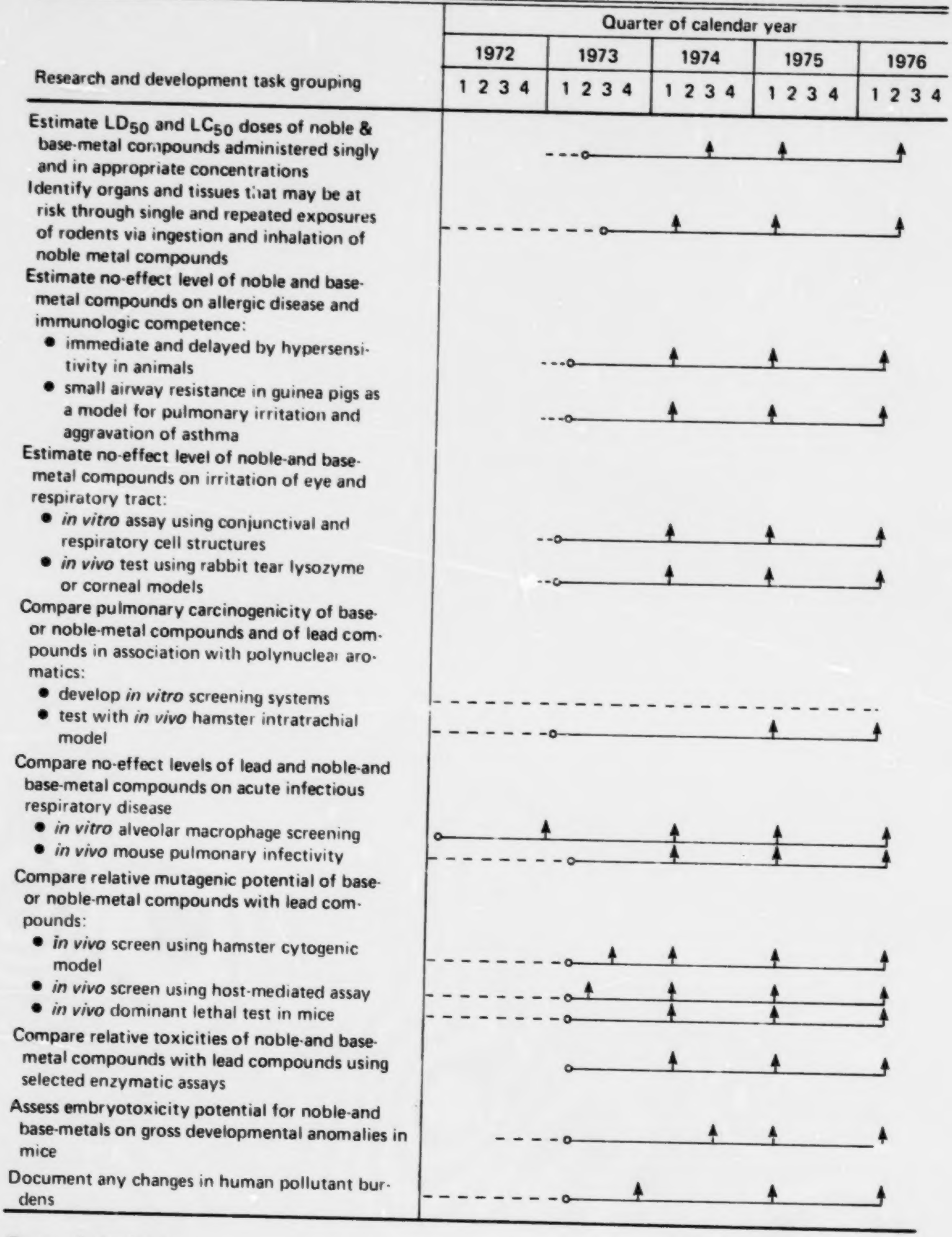
The Director of the Special Studies Staff is chairman of the air quality criteria panel. The required documents in Task III were formulated by an international panel with the U. S. representatives being responsible for drafting the documents and the Special Studies Staff having responsibility for having the documents reviewed and completed to publishable form.

In 1973, the NATO/CCMS document *Criteria for Nitrogen Oxides* was completed and published; *Criteria for Photochemical Oxidants and Related Hydrocarbons* was begun in 1973 but was not published until early in 1974.

The commitment to this project has been met; future activity is expected to be minimal.

World Meteorological Organization—The NERC-RTP's Meteorology Laboratory works closely with the World Meteorology Organization (WMO). WMO is now utilizing QAEML's aerometric data bank for storage and retrieval of aerometric data concerning rainfall and atmospheric turbidity.

Table 7. ACHIEVEMENT MILESTONES FOR TASKS TO ASSURE THAT PUBLIC HEALTH IS PROTECTED



Research and development task grouping

Estimate LD_{50} and LC_{50} doses of noble & base-metal compounds administered singly and in appropriate concentrations

Identify organs and tissues that may be at risk through single and repeated exposures of rodents via ingestion and inhalation of noble metal compounds

Estimate no-effect level of noble and base-metal compounds on allergic disease and immunologic competence:

- immediate and delayed by hypersensitivity in animals
- small airway resistance in guinea pigs as a model for pulmonary irritation and aggravation of asthma

Estimate no-effect level of noble-and base-metal compounds on irritation of eye and respiratory tract:

- *in vitro* assay using conjunctival and respiratory cell structures
- *in vivo* test using rabbit tear lysozyme or corneal models

Compare pulmonary carcinogenicity of base- or noble-metal compounds and of lead compounds in association with polynuclear aromatics:

- develop *in vitro* screening systems
- test with *in vivo* hamster intratrachial model

Compare no-effect levels of lead and noble-and base-metal compounds on acute infectious respiratory disease

- *in vitro* alveolar macrophage screening
- *in vivo* mouse pulmonary infectivity

Compare relative mutagenic potential of base- or noble-metal compounds with lead compounds:

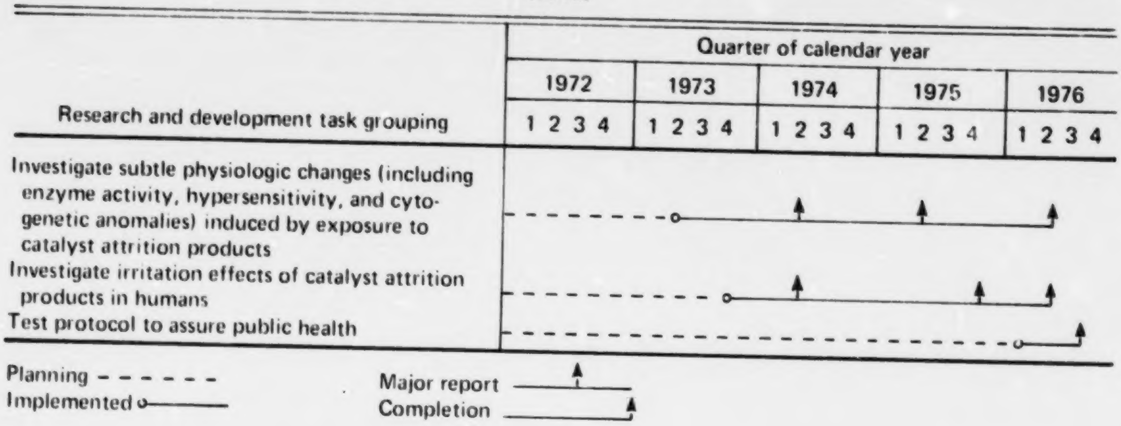
- *in vivo* screen using hamster cytogenic model
- *in vivo* screen using host-mediated assay
- *in vivo* dominant lethal test in mice

Compare relative toxicities of noble-and base-metal compounds with lead compounds using selected enzymatic assays

Assess embryotoxicity potential for noble-and base-metals on gross developmental anomalies in mice

Document any changes in human pollutant burdens

Table 7. ACHIEVEMENT MILESTONES FOR TASKS TO ASSURE THAT PUBLIC HEALTH IS PROTECTED (cont.)



Special Foreign Currency Program—The Special Foreign Currency Program (SFCP) provides for contracts for cooperative research. Contracts exist between NERC-RTP (via EPA's Office of International Affairs (OIA)) and institutions in Poland, India, and Yugoslavia. In Poland, SFCP studies are being done on control systems and biological effects related to effluents from coal-fired boilers and on biological action of radionuclides. In India, radionuclide effects are also being studied. There is interest in studies on air pollution control and on biological response to manganese. In Yugoslavia, studies are under way relative to biological effects of several metals and pesticides. There is interest in studying emissions and pollution control in selected industries.

NERC-RTP's staff participates as members of OIA-SFCP project teams. These teams have been engaged in such scientific fields as health effects, monitoring, modeling, and control technology. Team members have visited Yugoslavia, Poland, and Pakistan.

International Cooperative Agreements—Since 1969, there has been a cooperative agreement between the Federal Republic of Germany and the United States to coordinate research in five specified areas: health effects of automotive exhaust on humans; health and environmental effects of lead, including monitoring programs; effects of airborne nitrogen oxides; effects of airborne carcinogens; and health effects of asbestos, including the development of monitoring methods.

Since 1961, there has been a United States-Japan Cooperative Science Program. NERC-RTP is involved with both a working group on trace metals and a project on comparison of cardiorespiratory illness in matched groups in the two countries.

In February 1972, the protocol for a cooperative, tri-partite, cadmium-health effects project was developed and agreed upon for the United States-Japan-Sweden Tri-Partite Studies. This protocol requires each country to conduct research, on a collaborative basis, on measurement and biomedical aspects of exposure to cadmium.

A United States-U.S.S.R. Environmental Agreement, established in 1972, relates in part to biological and genetic effects of pollutants.

Initial discussions and scientific information exchange will involve epidemiology, mutagenesis, and heavy metals. NERC-RTP and other United States agencies will participate.

The overall U. S. objectives of all three programs would be to make it possible to get the maximum information input from the ongoing research in these area in the Soviet Union. It is clearly possible that the United States, by working with the Soviets, can both encourage an increase in the quality and quantity of environmental health research in both countries and have access to the research results produced by the Soviet scientists. This would significantly increase the research data base upon which all regulatory decisions are made. The long-term benefit, both to the United States and to the Soviet Union, would be a broadened information base on effects to environmental chemicals and physical factors on humans so as to permit the best possible regulatory decisions.

Another part of the Agreement deals with stationary source air pollution control technology. It is desirable to have exchanges of air pollution research and development information on the following subject areas:

- Sulfur oxides and particulate from thermal power plants.
- Gasification of coal and oil.
- Demetallization of residual fuel oil.

- Economic studies of desulfurizing methods.
- Physiochemical analysis of components in emissions from the iron and steel industry.
- Ice fog control.
- Catalytic oxidation process for sulfur oxide control.
- Control of emissions from coke ovens.
- Desulfurization and ash removal from coal by mechanical cleaning.
- Identification and control of emissions from coal- and oil-conversion processess.

It was agreed that, on problems requiring negotiations with industry groups or other government agencies in the United States, EPA would be responsible for coordination.

There is a United States-France cooperative program on "Physical Modeling Tests" with the French Meteorological Service and NERC-RTP's Meteorology Laboratory.

There is also a United States-Spain study, the Almaden Project, aimed at evaluating the effects of mercury, including the study of biological and environmental aspects. The project is just getting under way.

Economic Commission for Europe—The Control Systems Laboratory has cooperated with the ECE in conducting a seminar on air pollution control in the non-ferrous smelting industry.

Other Foreign Contracts—The Special Studies Staff is also involved with contracts involving Holland, The United Kingdom, and Sweden:

- A contract with the International Flame Research Foundation at its Research Station in Ijmuiden, Holland, relates to control of emissions from coal combustion. Programmed through Fiscal Year 1975, the contract involves NERC-RTP's Control Systems Laboratory.
- A contract with the Esso Petroleum Company Research Center, Abingdon, Berkshire, U.K., involves the chemically active fluid-bed combustion process. Programmed activity will continue through Fiscal Year 1975, possibly into Fiscal Year 1976, with NERC-RTP's Control Systems Laboratory.
- A contract with the Karolinska Institute in Sweden involves annual updating, via supplement, of the document, *Environmental Cadmium.* NERC-RTP's Special Studies Staff is party to the contract.

The Special Studies Staff will prepare periodic status reports for describing and summarizing all international activities associated with NERC-RTP. It is anticipated that there will be increased activity with WHO, SFCP, and cooperative agreements.

Human
Studies
Laboratory

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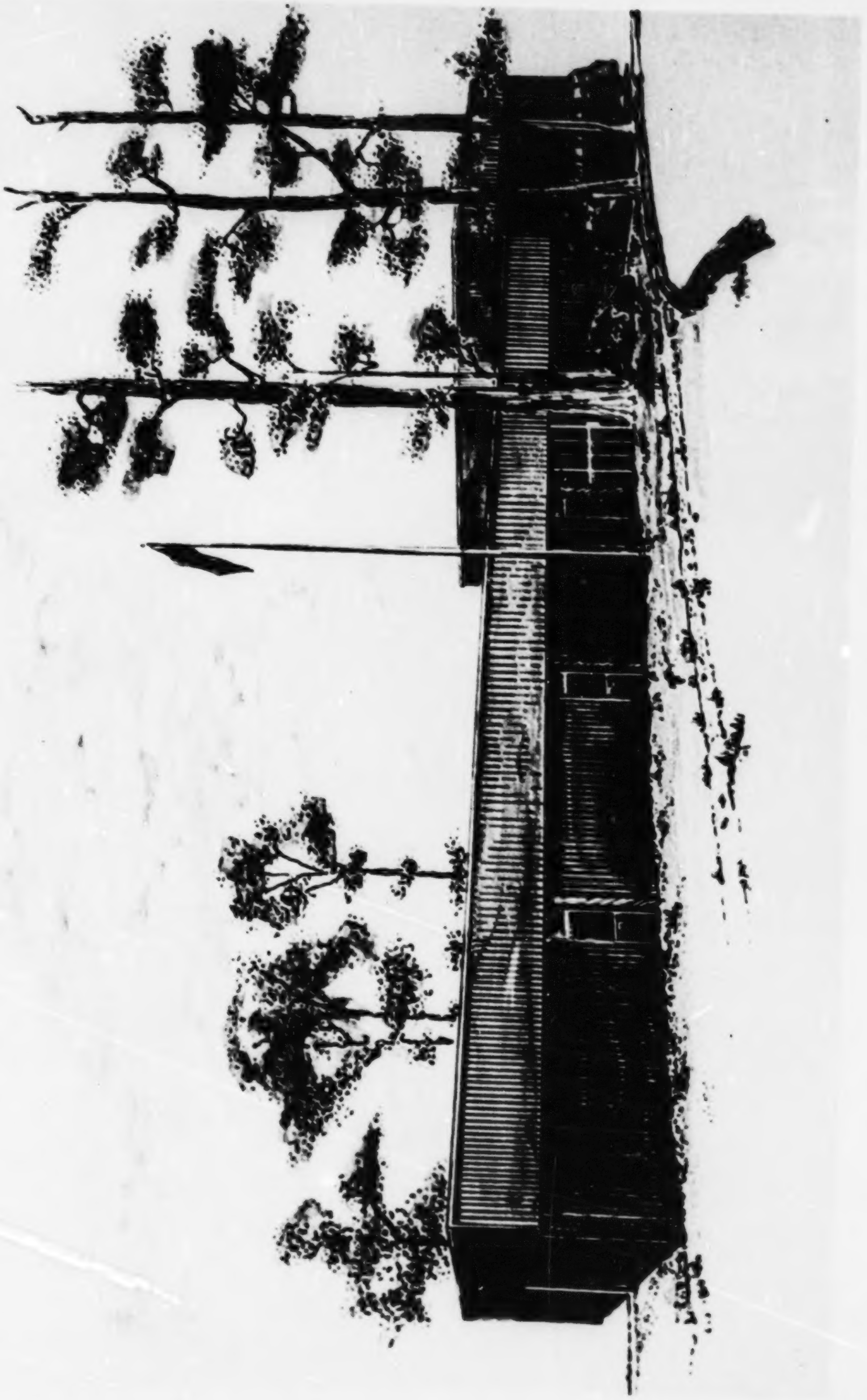
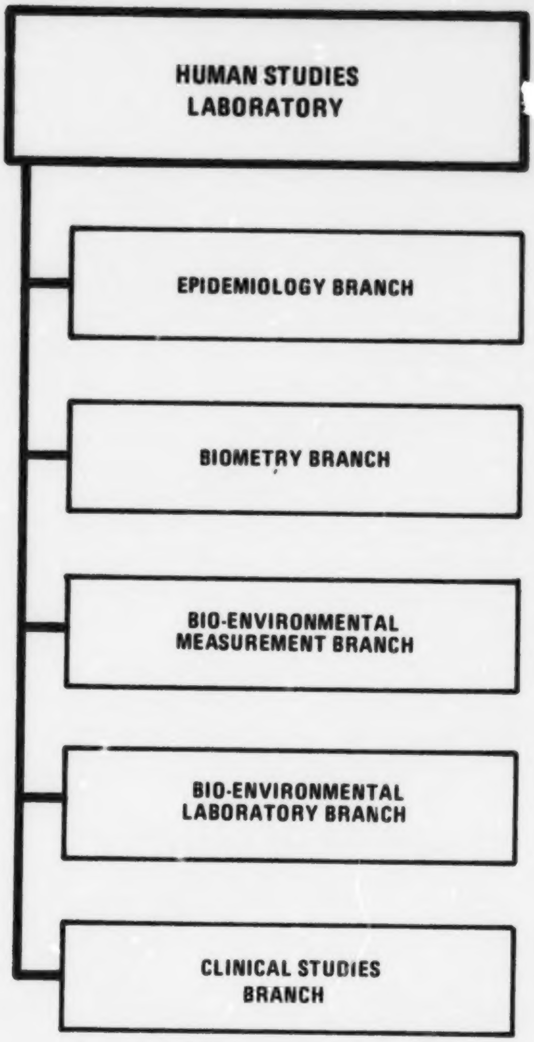


Human Studies Laboratory



Studies of the cardiopulmonary, psychophysiologic, metabolic, and immune responses of humans in controlled environmental laboratories are conducted at the Human Studies Laboratory branch located in the University of North Carolina Medical Center.

OVERVIEW OF HSL'S MISSION

The mission of the Human Studies Laboratory is to define the influence of environmental stress on human health so that appropriate steps can be taken to meet the requirements of the Clean Air Act. The Laboratory must also recognize and define new problem areas in environmental health as new technologies emerge. In addition, it must provide technical assistance to the Agency during pollution emergencies and during public hearings on control activities.

LEGISLATIVE MANDATE

HSL's research program is designed to meet the legislative mandate expressed in Section 103 of the Clean Air Act and in Section 241 of the Public Health Service Act. Specific sections of the Acts are shown below followed by brief descriptions of the types of actions taken by HSL in support of the mandates.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **"Sec. 103. (f) (1) In carrying out research pursuant to this Act, the Administrator shall give special emphasis to research on the short- and long-term effects of air pollutants on public health and welfare. In the furtherance of such research, he shall conduct an accelerated research program—**
>
> **"(A) to improve knowledge of the contribution of air pollutants to the occurrence of adverse effects of health, including, but not limited to, behavioral, physiological, toxicological, and biochemical effects; and**
>
> **"(B) to improve knowledge of the short- and long-term effects of air pollutants on welfare.**
>
> **"(2) In carrying out the provisions of this subsection the Administrator may—**
>
> **"(A) conduct epidemiological studies of the effects of air pollutants on mortality and morbidity;**
>
> **"(B) conduct clinical and laboratory studies on the immunologic, biochemical, physiological, and the toxicological effects including carcinogenic, teratogenic, and mutagenic effects of air pollutants;. . . ."**

In support of Section 103, HSL develops and conducts studies designed to define relationships between specific undesirable health effects and environmental pollutants, either individually or in combination. This research includes biochemical laboratory studies, clinical studies on human subjects, and epidemiological studies of human populations. Knowledge of the effects of short- and long-term exposure to environmental pollutants provides a basis for establishing national environmental or emission standards for those pollutants or source categories that endanger human health or welfare. In addition, the HSL research program is designed to evaluate the health benefits of improved air quality resulting from the establishment of emission standards. This program is also concerned with the decrement in health resulting from any future relaxation in air quality standards in response to the energy crisis. Analysis of the economic costs resulting from adverse health effects of pollution is an integral part of the HSL program.

Epidemiologic studies on the effect of radiation on humans come under the broad mandate of Section 241 of the Public Health Service Act, which is quoted in part below.

> **"THE PUBLIC HEALTH SERVICE ACT"**
>
> **"Sec. 241. Research and investigations generally. . .**
>
> **"The Surgeon General shall conduct in the Service, and encourage, cooperate with, and render assistance to other appropriate public authorities, scientific institutions, and scientists in the conduct of, and promote the coordination of, research, investigations, experiments, demonstrations, and studies relating to the causes, diagnosis, treatment, control, and prevention of physical and mental diseases and impairment of man . . . ."**

Under the broad mandate of Section 241, HSL studies the effects of ionizing radiation exposure on humans in cooperation with the Atomic Bomb Casuality Commission research program in Japan. HSL places major emphasis on evaluating the risk of adverse irreversible biological effects from exposure to various levels of different pollutants and in delineating the time lapse between exposure and disease (latent effects). Other studies conducted by the laboratory are concerned with the effects of non-ionizing radiations to which the general population is exposed. HSL resources committed in support of these acts are shown in Table 8.

ORGANIZATION

The HSL is divided into the Office of the Director and five Branches. The Office of the Director coordinates all Laboratory activities, develops long- and short-term research goals, and periodically reviews the progress of Laboratory programs.

The Epidemiology Branch studies the effects of pollution on human health and searches for predisposing factors that worsen or contribute to the development of various diseases. In addition, the Branch assesses the impact upon health and welfare of improvements in environmental quality resulting from efforts to control pollution.

The Biometry Branch is responsible for the design and analysis of research studies and provides statistical design and analysis, computer programming, and data processing services. The Branch conducts research in statistical and computer-oriented areas related to the mission of the Laboratory.

Table 8. SUMMARY OF RESOURCES FOR HUMAN STUDIES LABORATORY FOR FISCAL YEAR 1974[a]

Category	Funds, $\$10^3$	Positions	Approximate percent
Clear Air Act, Section 103	8461.0	104.0	97
Public Health Service Act, Section 241	299.0	9.0	3
Total	8760.0	113.0	100

[a] Does not include $3.4 million of special energy appropriations.

The Bio-Environmental Measurement Branch conducts a comprehensive program of environmental measurements of pollutants in controlled laboratory environments and in ambient polluted environments. These measurements are related to the physiological and pathological responses of human subjects exposed to environmental pollutants in bio-medical laboratory studies and of selected segments of the populations in epidemiologic studies.

The Clinical Studies Branch conducts laboratory studies to detect and define effects of environmental pollutants on human health, to verify correlative epidemiological findings, and to develop or improve methodology for application to human health effects studies in the laboratory and in community settings.

The Bio-Environmental Laboratory Branch (BELB) works in cooperation with the other Branches of HSL to describe human metabolic response to pollutant exposure. The BELB program includes performing chemical analyses of environmental and biological samples, as well as conducting research to determine appropriate methodology for the analyses of trace environmental or biological specimens. The Branch is also developing methods for determining the level of human exposure to various pollutants. The objective is to demonstrate a dose/response relationship for exposure to a given pollutant species and a specific metabolic parameter prior to permanent or serious injury.

PHYSICAL FACILITIES

The Human Studies Laboratory has facilities at NERC-RTP and in Chapel Hill, North Carolina. Laboratories in both locations are equipped with the most modern analytical instruments, including gas/

liquid chromatographs, an atomic absorption spectrometer with heated graphite atomizer, ultra-centrifuges, disc gel and slab electrophoresis devices, radioactive strip scanning devices, and liquid scintillation spectrometers.

Twenty-three Community Health and Ambient Monitoring Program (CHAMP) stations are being updated and equipped with the best technology available in sensors complemented by automatic electronic data acquisition with remote magnetic tape storage and "on-call" telemetric output and visual field data inspection.

The Clinical Studies Branch is located in the Clinical Environmental Research Laboratories building on the periphery of the University of North Carolina Medical Center complex in Chapel Hill. This special-purpose building was constructed specifically to assist in fulfilling EPA medical research objectives and to provide special-purpose laboratories and support areas. These special-purpose laboratories include:

- Controlled human exposure facilities in which varied exposures to air pollutant concentrations or noise levels can be produced.
- Cardiovascular research facilities for validating measurement techniques and for obtaining cardiovascular data from studies on animals and humans.
- Psychophysiology facilities in which human behavioral and psychophysiologic studies are conducted.
- Microbiology facilities in which effects of environmental stress and human immune mechanisms are studied.
- Pulmonary physiology facilities in which new techniques for human pulmonary function measurement are developed and validated.
- Clinical metabolism facilities in which routine and specialized human clinical chemistry analyses are performed.
- Pulmonary research facilities at the Frank Porter Graham Child Development Center in Chapel Hill, the exercise physiology laboratory, and the pathology laboratories in which specialized research is conducted.

In addition to the above facilities, HSL has an optical reader for directly processing health questionnaire data onto magnetic tape and computer terminals that provide direct access to EPA's Computer Center at NERC-RTP.

MAJOR PROGRAM AREAS

HSL research activities are in two major program areas: field epidemiological studies in ambient pollution exposure situations and clinical (laboratory) studies on human subjects under experimentally produced exposure conditions. The various studies are integrated or complementary in a manner designed to provide the broadest possible response to the needs of the Agency.

Epidemiological Studies

Current Activities—Studies conducted in 13 communities of the Community Health and Environmental Surveillance System (CHESS) provide gradients of exposure to total suspended particulate, respirable suspended particulate, sulfur dioxide, nitrogen dioxide, suspended nitrates, suspended sulfate, and photochemical oxidants. Also, autopsy tissues were collected in each of the CHESS cities to derive new health intelligence concerning the levels of trace metals and other multimedia toxic substances in humans. Those epidemiological activities consist of measurements of sensitive, acute, and chronic health indicators in demographically similar populations exposed to a gradient of ambient levels of specific air pollutants. Because data are being collected during years in which communities achieve state implementation plans, these studies may document the health benefits of pollution control. CHESS may also assess the health impact of changing energy patterns as power plants shift from low- to high-sulfur fuels, and from gas and oil to coal.

Epidemiological studies also involve the orderly installation, check-out, calibration, and maintenance of the Community Health Air Monitoring Program (CHAMP) measurement devices. CHAMP is a key element of the CHESS program and is designed to provide short-term measurements of air quality exposures within the CHESS areas. Data are recorded on site by automated methods compatible with EPA computer standards and are retrieved through a system employing sequential, automatic polling of all field stations. If emergency atmospheric conditions exist in any area at the time of polling, an alarm is sounded and the emergency condition is displayed for reporting to Federal and local agencies.

Two computerized, mobile clinical laboratories have been designed and are now being constructed. They will give a new level of sophistication to epidemologic studies in Fiscal Year 1975.

Major Accomplishments—Major field study accomplishments during the fiscal year period of this report involved the CHESS program. The CHESS program included 31 neighborhoods in 6 areas of the country: the interurban area of New York and New Jersey; the State of Utah; the cities of Chattanooga, TN, Birmingham, AL, and Charlotte, NC; and the Los

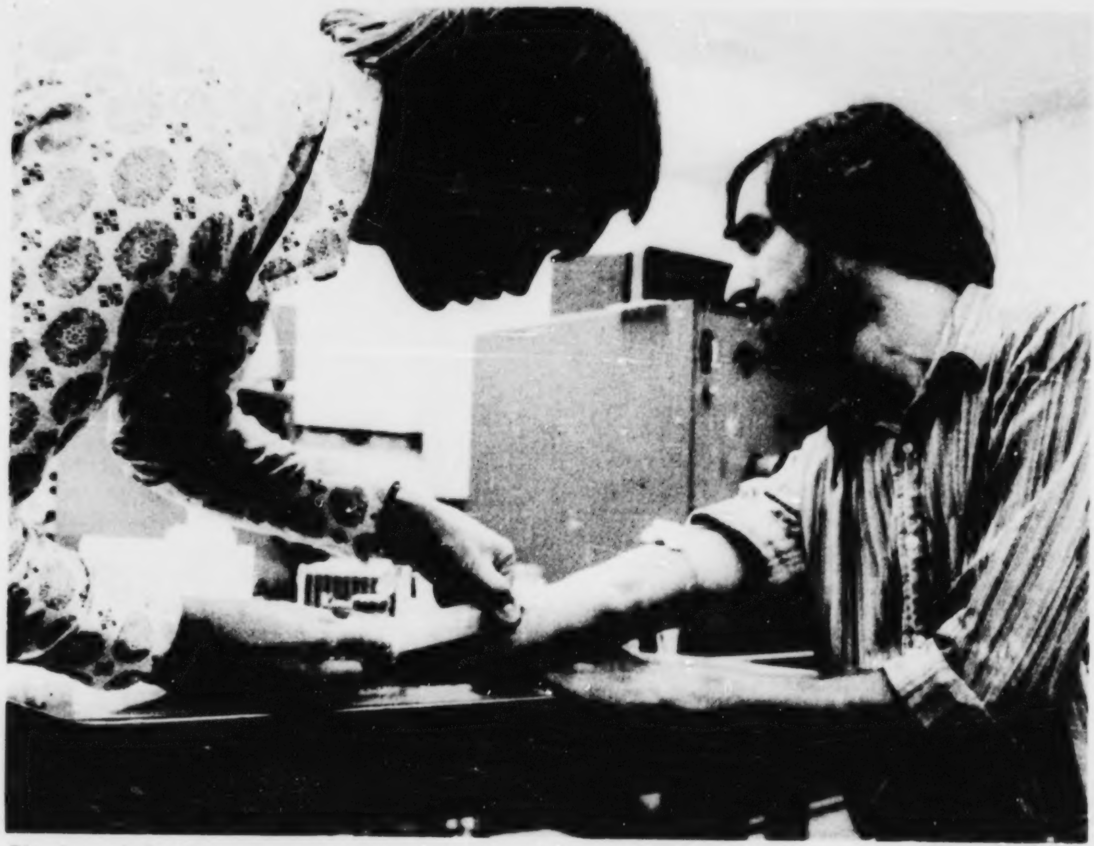
Angeles basin. The six health indicators under surveillance in these neighborhoods included chronic respiratory disease in adults, acute lower respiratory disease in children, frequency of daily asthma attacks, pulmonary function of school children, residue of cumulative pollutants in human tissue, and daily aggravation of symptoms in subjects with pre-existing heart and lung disease.

Major research involving a specific group of pollutants culminated in the publication of the EPA monograph, *Health Consequences of Sulfur Oxides: A Report from CHESS, 1970-1971.* (EPA-650/1-74-004).

Draft reports from field studies of the CHESS program for 1971-1972 for the CHESS neighborhoods in New York and in the Southeastern cities were completed on the effects of respirable particulates. These studies reflected the benefits of improved air quality as pollution control plans were implemented. Analyses and preparation of reports pertaining to nitrogen dioxide and oxidants are underway for 1971-1972 in the Los Angeles Basin and in Chattanooga.

Data from the Southeastern cities suggest that particulates in the presence of low levels of sulfur dioxide are associated with decrements in pulmonary function and increases in lower respiratory disease morbidity in school children. The most important finding resulting from the New York-New Jersey area studies was that the health indices of chronic respiratory disease in adults, lower respiratory disease in children, and pulmonary function results did not vary across the four New Jersey communities exposed to similar long-term pollutant levels. The finding confirmed the belief that people living in areas with similar pollution levels would demonstrate similar health indices.

The first phase of an epidemiologic study confirmed that an increase in congenital anomaly rates had occurred at a military base at which a significant amount of radar surveillance is used. This study will be expanded to obtain data on factors other than



Blood sample for chromosome analysis is drawn from volunteer exposed to ozone in laboratory test.

radar exposure that might explain the observed increase.

Future Research Emphasis—The CHESS program will continue to seek data delineating the dose/response effects of exposure to pollutants and describing the human health benefit of control actions. Timely reporting of CHESS results will enable the Agency to evaluate the impact of existing standards, the need for revised standards, and the desirability of taking new control action.

The completion of a new research facility will facilitate rapid dose/response studies of human exposure to gaseous pollutants, and particulates.

Other major efforts will be directed toward:

- Completion of reports on the health consequences of exposure to respirable particulates, nitrogen dioxide, carbon monoxide, and oxidants.
- Completion of analyses of health and exposure data collected under CHESS field studies during 1972-1973.
- Cooperation with National Science Foundation, National Bureau of Standards, and Atomic Energy Commission in establishing a National Tissue Bank.
- Refining the estimate of the dose/response curve relating to the development of thyroid tumors in children exposed to diagnostic doses of radioactive iodine.
- Preparation of a report on the benefits of controlling automobile pollution that will include a review of past studies and propose research to obtain better benefit estimates.
- Investigation of the health effects associated with the normal operation of sewage plants and the application of effluents in agriculture.
- Completion of installation and conversion to the Univac 1110 computer system to increase the quantity of data processed per unit of time.

Clinical Studies

Current Activities—Human clinical studies include investigations of the effects of short-term, low-level exposure to carbon monoxide, ozone, and nitrogen oxides. Physiological measurements include cardiovascular response to pollutant exposure under varying degrees of physical stress (exercise).

Clinical studies have been initiated to investigate growth and development of children's lungs in low pollution environments using pulmonary function measurements. The results of this study should provide a baseline for comparing pulmonary function in clean versus polluted environments.

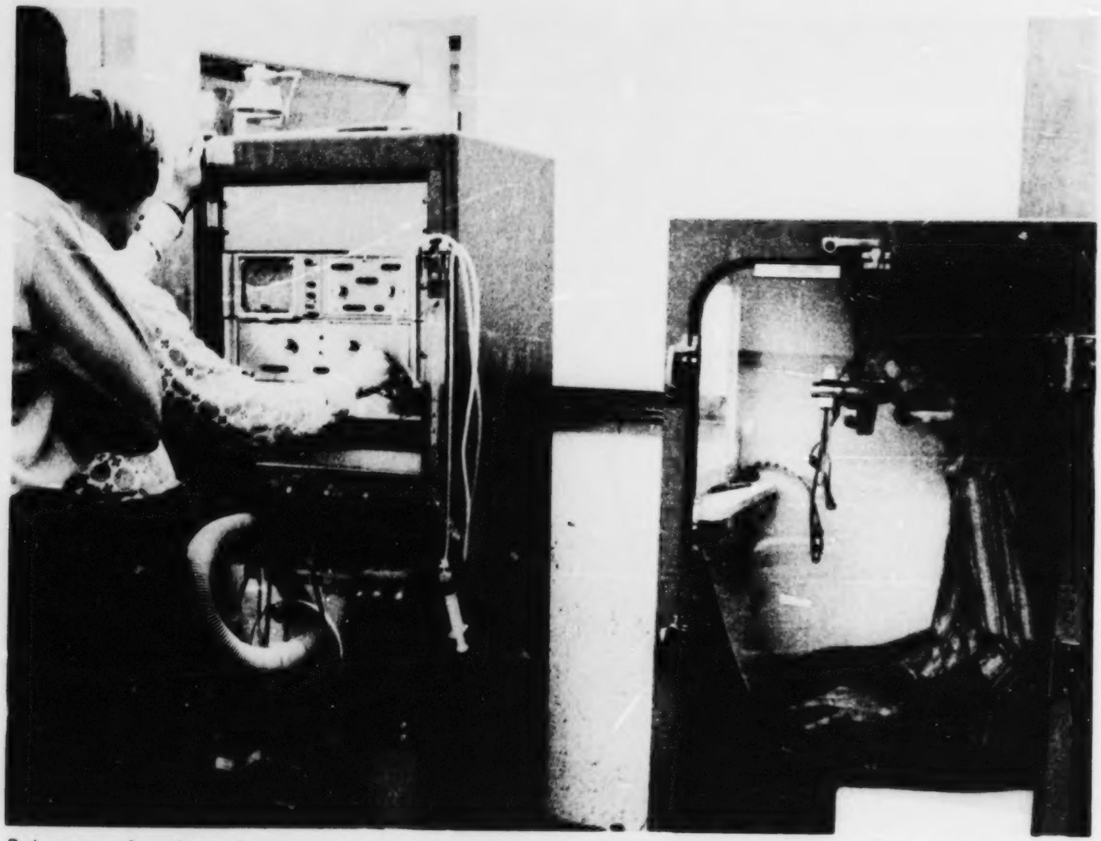
Volunteer is asked to exercise during exposure to ozone in environmental chamber to test pollutant effects.

Other studies have been initiated to measure changes in pulmonary function and to identify chromosomal aberrations from controlled short-term, low-level exposure to the photochemical oxidants (nitrogen oxides and ozone) that are known to be present in the polluted atmospheres of our cities.

The effects of noise levels on humans is also under investigation.

The Clinical studies program also involves the design, procurement, fabrication, and installation of human exposure facilities and the equipping of a mobile clinic. The facilities allow researchers to control temperature and humidity and to maintain the desired levels of aerosols and gases, either singularly or in combination.

Physiological sensors incorporating most recent advances in the state-of-the-art have been incorporated in these facilities. The operation of these physiological monitors requires the combined talents of physicians, engineers, biologists, psychologists, and technicians.



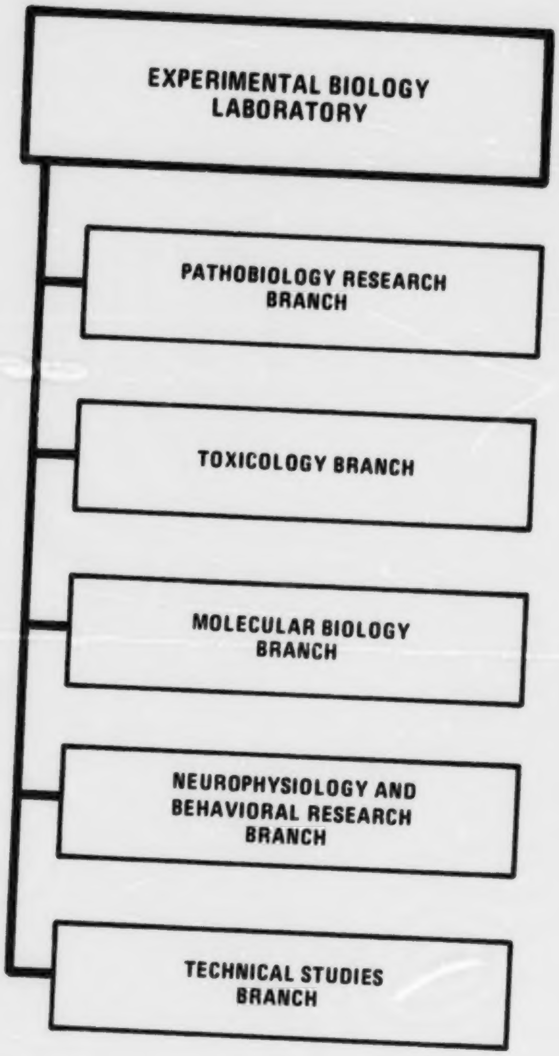
Pulmonary function of volunteer exposed to ozone in laboratory is tested to evaluate pollutant effects.

Clinical Study Major Accomplishments—Studies of non-smokers exposed to 0.5 ppm of ozone for 6 hours indicate a significant decrement in ventilatory function measurements. A high positive correlation was found between severity of irritation symptoms (chest pain, cough, phlegm, etc.) and decrement in ventilatory function measurements. These findings reflect results similar to those from animal exposure studies. Smokers, on the other hand, showed no decrement in ventilatory function after exposure to 0.5 ppm of ozone for 6 hours.

Preliminary results from controlled exposure tc oxidants suggest that ambient air concentrations of the pollutants in a number of our cities could be sufficiently high to cause identifiable chromosomal aberrations in humans.

Experimental
Biology
Laboratory

Experimental Biology Laboratory


EXPERIMENTAL BIOLOGY LABORATORY
PATHOBIOLOGY RESEARCH BRANCH
TOXICOLOGY BRANCH
MOLECULAR BIOLOGY BRANCH
NEUROPHYSIOLOGY AND BEHAVIORAL RESEARCH BRANCH
TECHNICAL STUDIES BRANCH

Studies to determine biological effects of low-level microwave irradation are conducted by the Experimental Biology Laboratory.

OVERVIEW OF EBL'S MISSION

Experimental Biology Laboratory research is directed toward studies relevant to the development of environmental standards for the protection of human health and welfare, particularly as such standards relate to gaseous and particulate air pollutants, to ionizing and nonionizing radiation, and to interactions among pollutants. Studies using laboratory animals or biological preparations complement human epidemiological and clinical programs by validating data from human studies, providing clues to new human studies, developing toxicity data for extension to humans, and indicating the potential harmful effects of new pollutants. These studies require the coordinated contribution of chemists, engineers, and representatives of a wide variety of biological disciplines. The Laboratory possesses particular expertise in the areas of animal toxicology, radiation biology, neurobiology, and microwave engineering.

LEGISLATIVE MANDATE

EBL's programs support Section 103 of the Clean Air Act and Section 241 of the Public Health Service Act. The relevant sections of the Acts are shown below followed by brief descriptions of the types of actions taken by EBL to support them.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **"Sec. 103. (f) (1) In carrying out research pursuant to the Act, the Administrator shall give special emphasis to research on the short- and long-term effects of air pollutants on public health and welfare. In the furtherance of such research, he shall conduct an accelerated program-**
>
> **"(A) to improve knowledge of the contribution of air pollutants to the adverse effects of health, including, but not limited to, behavioral, physiological, toxicological, and biochemical effects; and**
>
> **"(B) to improve knowledge of the short- and long-term effects of air pollutants on welfare.**
>
> **"(2) In carrying out the provisions of this subsection the Administrator may--**
>
> **"(A) conduct epidemiological studies of the effects of air pollutants on mortality and morbidity;**
>
> **"(B) conduct clinical and laboratory studies on the immunologic, biochemical, physiological, and the toxicological effects including carcinogenic, teratogenic, and mutagenic effects of air pollutants; . . . ."**

EBL programs in support of Section 103 include studies on the effects of the regulated pollutants (ozone, nitrogen oxides, sulfur oxides, and particulates) and the non-regulated pollutants (particulate sulfate and nitrate, fine particulates from industrial sources, trace metals, etc.) using appropriate whole animal, organ, cellular, or sub-cellular models. Particular emphasis has been given to the effects of pollutants on pulmonary defense mechanisms and pulmonary carcinogenesis and to the influence of interactions between coexisting pollutants and various physical factors upon these pulmonary responses. The potential mutagenicity of photochemical oxidants is also under investigation. Programs are under development to examine the effects of prenatal and neonatal, as well as adult, exposure to photochemical oxidants and carbon monoxide upon subsequent growth and development (including development of behavioral patterns).

> **"THE PUBLIC HEALTH SERVICE ACT**
> **"Sec. 241. Research and investigations generally**
> **"The Surgeon General shall conduct in the Service, and encourage, cooperate with, and render assistance to other appropriate public authorities, scientific institutions, and scientists in the conduct of, and promote the coordination of, research, investigations, experiments, demonstrations, and studies relating to the causes, diagnosis, treatment, control, and prevention of physical and mental diseases and impairment of man, including water purification, sewage treatment, and pollution of lakes and streams . . . ."**

The "causes . . . of . . . diseases" cited in Public Health Service Act Section 241 include ionizing and non-ionizing radiation. The responsibility to provide Federal guidance on all radiation matters affecting health and the authority to establish environmental standards for the protection of the general environment from radioactive material rests with EPA. EBL programs related to ionizing radiation are centered on tritium and krypton-85, two of the major effluents from nuclear fuel reprocessing plants, and are designed to provide a more secure data base for prediction of potential health effects than is currently available. The Laboratory also conducts an extensive program on the health effects of electromagnetic non-ionizing radiation. Emphasis is placed on the potential mutagenic, teratogenic, and neurobiological effects—and mechanisms of interaction at the cellular and subcellular level—of radiations of frequencies ranging from 500 megahertz (MHz) to 10 gigahertz (GHz). Table 9 presents a summary of resources employed for EBL during Fiscal Year 1974.

Table 9. SUMMARY OF RESOURCES FOR EXPERIMENTAL BIOLOGY LABORATORY FOR FISCAL YEAR 1974

Category	Funds, $\$10^3$	Positions	Approximate percent
Clean Air Act, Section 103	1896	20	62
Public Health Service Act, Section 241	1180	47	38
Total[a]	3076	67	100

[a] Does not include $0.5 million of special energy appropriations.

ORGANIZATION

The Office of the Director ensures integrated application of the multi-disciplinary expertise available within the five branches in research projects designed to develop information pertinent to formulation and revision of environmental quality criteria in support of human health studies.

The Pathobiology Research Branch is primarily concerned with the investigation of air pollutants as they relate to acute and chronic respiratory disease and pulmonary carcinogenesis, and as they affect an organism's mechanisms of defense against infectious agents, using whole animal and *in vitro* model systems. Particular emphasis is given to interactions between chemical, biological, and physical insults. The Branch also has responsibility for development of rapid throughout *in vitro* screening systems for determining the relative toxicity of gaseous and particulate air pollutants.

The Toxicology Branch investigates the gross teratologic, reproductive, developmental, and genetic effects of a variety of environmental pollutants, together with late effects such as tumor production and life span shortening. Originally concerned largely with the toxicology of radioactive materials, the Branch has extended its activities to studies of the biological effects of nonionizing radiation and of the interactions between radiation and other existing environmental pollutants.

The Molecular Biology Branch's principal interest is the interaction of radio frequency and microwave radiation with biological systems at the subcellular and molecular level, with particular attention being given to effects on the genetic material and other macromolecules and on the organelle and cell membranes. The Branch's expertise in microbiology, biochemistry, and physical chemistry and in electron spin resonance techniques is also being applied to studies on the toxicity of tritium and heavy metals and on the extrapulmonary toxicity of photochemical oxidants.

The Neurophysiology and Behavioral Research Branch investigates possible adverse effects of environmental contaminants on the nervous system in animal models and develops research methodology in the area of neurobiology applicable to the study of human populations. The members of the Branch function as an interdisciplinary team to study responses of behavioral, electrophysiological, neurohumoral, and related physiological parameters to exposure to chemical and physical stressors including air pollutants, pesticides, and ionizing and non-ionizing radiation. The Branch serves as the focal point for coordination of neurobiologic research for NERC-RTP.

The Technical Studies Branch provides support to the Laboratory through the development and maintenance of equipment and instrumentation necessary for biological effects research, particularly in the area of electromagnetic non-ionizing radiation. The Branch also coordinates the Laboratory's computer services and provides computer programs to support biological activities. The Branch conducts research in the dosimetry of non-ionizing radiation and the application of dosimetric techniques to biological studies.

PHYSICAL FACILITIES

The Laboratory possesses facilities for exposure of laboratory animals (via inhalation) to gaseous materials and aerosols under controlled conditions of air flow, temperature, and humidity and for exposure (via inhalation and whole-body exposure) to radioactive gases (currently krypton-85) over long periods under beta-infinite cloud conditions.

Facilities that permit exposure to a range of radio and radar frequency radiations are available or under construction. These facilities include two large anechoic chambers for use at S- and X-band frequencies, both with environmental control systems; a strip-line facility for whole-body exposures of small mammals over the VHF, TV, and UHF ranges; and numerous custom-built airline systems for irradiation of cellular, subcellular, and molecular preparations at frequencies upward from 200 MHz.

Electrophysiological recording instrumentation and behavioral testing chambers (housed in RF-shielded and/or sound-attenuated rooms), with associated laboratory computers, are available for neurobiological studies.

For measurement of concentrations of paramagnetic species and free radicals, an electron spin resonance spectrometer with a 9-inch electromagnet and a double cavity is available. The system also includes frequency measuring equipment for precise g-value determinations to characterize and identify unknown species. Additionally, the associated variable temperature unit permits determination of free radical reaction rates and matrix trapping ability from 80°K to 370°K.

MAJOR PROGRAM AREAS

Air Pollutants

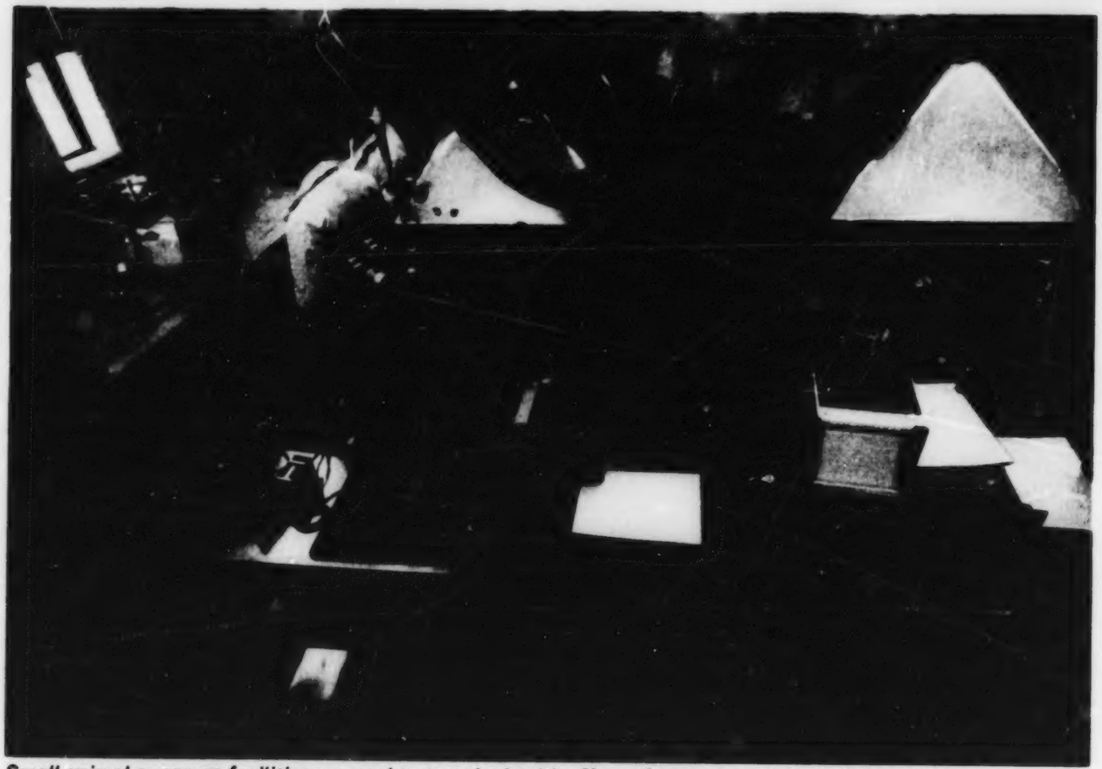
Research on pulmonary defense mechanisms utilizes animal model systems to investigate effects of air pollutants on the upper and lower respiratory system as reflected by such parameters as physical clearance rates, persistence of bacteria, and exacerbation of existing infections. EBL research has shown that hydrogen chloride gas has no effect upon the aforementioned parameters but does produce anatomical changes in the nasal cavity. In relation to pulmonary infection, EBL studies show that the concentration of nitrogen dioxide (NO_2) is of much greater importance than the time of exposure to the pollutant. Exercise was found to enhance the susceptibility to pulmonary infection of mice exposed to ozone. During a sequential exposure to ozone and No_2, when ozone was given first, there was no additive effect of NO_2; whereas, when NO_2 was given first, there was an additive effect to ozone. This result suggests an immediate tolerance development wherein the ozone has a stronger tolerance-inducing effect than does NO_2. In another EBL study, NO_2 in concentrations of greater than 10 ppm for 30 minutes failed to alter complement or immunoglobulin levels in rabbits, either *in vivo* or *in vitro*. An antialveolar macrophage serum was successfully developed, but preliminary results have indicated that its non-specific serum effect may override its specific effect upon macrophages.

Extramural research in support of EBL activities includes studies designed to evaluate the relative effects of exposure of mice to peak versus continuous concentrations of NO_2. Parameters studied have included resistance to viral and bacterial infection, immunoglobulin and complement levels, antibody titers, and pulmonary pathology. Currently, effects on cell-mediated immunity are under investigation. Longer term studies in rats and monkeys are being extended to newborn animals to examine the effects of age on the genesis of emphysema from NO_2 exposure.

Reports on the potential mutagenic role of ozone have led to reevaluation of its extrapulmonary effects. Initially, confirmation of ozone's apparent ability to induce chromosome aberrations in circulating lymphocytes is being sought. Following this study, effects on transmissible translocations will be examined. A limited experiment to examine the potential for induction of extrapulmonary tumors is also being conducted.

Implication of acid mists and sulfate particulates as correlates of respiratory disease through human epidemiological studies led to the development of a program to evaluate factors affecting the toxicity of

Patterned behavior in rats exposed to pollutants is analyzed using closed circuit television coupled with computer methodology.



Small animal exposure facilities are used to test the health effect of gaseous and particulate pollutants.

fine particulate materials. The role played by particle size and composition, and by interacting factors such as humidity, temperature, and the presence of sodium chloride is being studied in suitable animal models using sulfates of known composition and mixtures generated through the interaction of sulfur dioxide, ozone, and olefins.

Benzo[a]pyrene (BaP) is being used as a model compound in studies of the part played by environmental polycyclic hydrocarbons in the induction of pulmonary cancer. Preliminary studies have involved endotracheal administration of BaP, either alone or combined with metallic oxides. Parallel studies employ airborne particulates containing hydrocarbons collected from ambient air.

Work on the effects of oxidant gases on rabbit alveolar macrophages *in vitro* led to the development of systems, using alveolar macrophages and human lung fibroblasts in tissue culture, for the rapid evaluation of the relative cytotoxicity of environmental pollutants. Originally applied to trace metals (cadmium, vanadium, nickel, manganese, and chromium) known to occur in fine particulates in ambient air, these evaluative systems are now being used to examine fly ash and other fine particulates from industrial effluents, and noble metal compounds and other attrition products from automobile catalytic converters. The systems have also proved useful in permitting rapid identification of biochemical and cytological lesions that might impair critical cell functions such as biosynthetic or phagocytic activity.

Future plans call for expansion of studies on the extrapulmonary effects of three regulated air pollutants, ozone, nitrogen dioxide, and carbon monoxide. These studies will concentrate initially on the effects of prenatal and neonatal exposure on growth and functional development, particularly of the cardiovascular and central nervous systems, of small laboratory animals. Research at EBL will continue to be focused on the elucidation of the health effects of pollutant interactions, expanded to include such pollutants as particulate sulfate and particulate nitrate. Such studies are needed to permit the continued assessment of the adequacy of environmental standards and to provide assurance that new technologies present no environmental health hazards.

Ionizing Radiation

Programs in radiation health effects research are presently confined to tritium and krypton-85, two major effluents from the reprocessing of nuclear fuel.

Tritium—The principal areas of research on tritium during the reporting period have been the effects of tritiated water (HTO) on embryos, on the central nervous system, and on tumorigenesis, life span, and reproduction. The common focus of this research is to determine the adequacy of the existing standards for the exposure of the population to tritium.

The embryonic and fetal stages are considered the most radiosensitive periods of life. A current extramural study using pre-implantation mammalian embryos is designed to identify the radiosensitive stages in the developmental process and to correlate pre-implantation and developmental anomalies with post-implantation death. The early zygote stage has been shown to be the most sensitive. Comparisons of the relative biological effectiveness (RBE) of tritium and strontium beta radiations, X-radiation, and cobalt-60 gamma radiation in producing these end-points have shown that the RBE for tritium is unity.

During early development, the central nervous system is particularly vulnerable to irreversible damage. Previous work has shown that the brain size and weight of new-born laboratory animals continuously irradiated during the gestation period were significantly lower than in unirradiated controls and that the reduction was linearly proportional to dose. A study has now been undertaken to determine if there are associated neurochemical changes—specifically in levels of the neurotransmitters, norepinephrine (NE) and dopamine (DA) and in concentrations and activities of the enzymes, monoamine oxidase (MAO) and acetylcholinesterase (AChE). MAO, AChE, and DA contents of the brain were unaltered by HTO treatment. The NE concentration in brains from irradiated animals increased significantly between 2 and 45 days after birth at total doses as low as 66 rads. Increased NE levels have been associated with behavioral abnormalities such as hyperactivity.

Production of tumors and non-specific shortening of life are two of the principal delayed effects of whole-body irradiation. A long-term, dose/response study of female rats exposed continuously to HTO over the gestation period and of their offspring has been underway for more than 2 years. During the reporting period, data collection on the parental generation was completed. The life span of dams receiving total doses of from 66 to 660 rads was significantly shortened over that of unirradiated female rats. An increased incidence of mammary neoplasia following doses of 330 and 660 rads was also observed.

In real life, humans are exposed to environmental tritium from conception throughout the life span, a period that would normally include the production of another generation. Genetic damage resulting from continuous low-level radiation may accrue and possibly be manifested and magnified in subsequent generations. Studies involving the continuous exposure of rats to HTO from conception through production of the third (F_2) generation have been performed. The exposure levels used were 2, 20, 200, and 2000 times the standard (MPC_w) for continuous exposure to HTO by an individual in the general population. The results of the rat study showed that lifetime parental exposure produced effects in the F_2 generation at levels 10 to 100 times lower than those required for the same effects after *in utero* exposure alone. Statistically significant reductions in the relative brain weights of F_2 neonates were noted at doses as low as 20 times the MPC_w.

Behavioral studies are planned to complement the gross teratologic and neurochemical research described above. Studies are underway to ascertain the age segment of the population most sensitive to chronic HTO irradiation using reproductive, hormonal, and neurochemical end points.

Krypton-85 - Research into the physiological behavior and radiation effects of krypton-85 is designed to provide data for a realistic assessment of the hazards of exposure to this noble gas.

Whole-body partition coefficients and kinetic behavior of ^{85}Kr are being studied in several species. In guinea pigs, the saturation and desaturation curves have been shown to be multi-exponential, usually with 4 components with half-times of 0.25 to 2.2 minutes, 6 to 12 minutes, 21 to 42 minutes, and 88 to 178 minutes. The whole-body weight partition coefficient $[(\mu Ci\,^{85}Kr/g\ \text{guinea pig})/(\mu Ci\,^{85}Kr/cm^3\ \text{air})]$ for adult guinea pigs was found to be 0.1444 (Standard Deviation = 0.0148). Comparison with preliminary data from rats and fragmentary partial body data from humans indicates that saturation/desaturation rates are inversely related to the size of the animal.

The equilibrium concentrations of ^{85}Kr in various organs and tissues of guinea pigs and hamsters breathing ^{85}Kr at known concentrations are being determined to evaluate radiation doses delivered to radiosensitive tissues. *In vivo* weight partition coefficients have been obtained for blood and 22 organs and tissues in guinea pigs. The highest coefficients (for bloodless tissue) were: omental fat, 0.4213; subcutaneous fat, 0.4056; thymus, 0.2588; lymph nodes, 0.1375; bone marrow, 0.1312; and adrenals, 0.1017.

The median lethal exposure for ^{85}Kr administered to guinea pigs by inhalation with the outside of the body protected, together with the associated hematology and pathology, is being studied to correlate tissue distribution findings with effects. The 30-day median lethal exposure has been determined to be 4450 microcuries per cubic centimeter per hour, which corresponds to estimated doses of 316 rads to bone marrow, 340 rads to whole body, and 7876 rads to lung. The gross clinical and necropsy observations were consistent with death from the hematopoietic syndrome, but lung injury was dominant in animals that survived for more than 30 days.

Guinea pigs (in the natural state or clipped), rats, and Chinese hamsters are being exposed to ^{85}Kr in beta infinite geometry to determine the acute median lethal exposure for each species and the associated hematological and pathological changes. The skin dose necessary to cause clinically observable damage is of particular interest. To date, guinea pigs have been exposed at surface doses up to 15,000 rads. The only effects observed were some erythema, mild to severe beta burns on the ears, and mild burns on the nose. The animals are being retained for long-term observation.

Future plans call for chronic exposure studies designed to develop a dose/effect relationship for induction of skin cancer in rats and, possibly, Chinese hamsters.

Nonionizing Radiation

EBL's programs in non-ionizing radiation research are conducted as part of a multi-agency "Program for Control of Electromagnetic Pollution of the Environment: The Assessment of Biological Hazards of Non-ionizing Electromagnetic Radiation" coordinated by the Office of Telecommunications Policy.

Animal models (whole animals and cellular, subcellular, or molecular preparations as appropriate) are used to investigate potential damage including genetic, biochemical, immunological, and neurobiological effects—from exposure to radio and microwave frequencies similar to those found in the environment. Studies are designed to identify potential harmful effects, to establish the exposure levels at which these effects are elicited, and to delineate the mechanisms of physical alterations. These studies will provide a data base for the promulgation of standards governing the exposure of the population to nonionizing radiation.

Attempts have been made to confirm reports that microwave radiation will inhibit the growth of bacterium, *E. coli*. The phenomenon, if real, is of great potential significance. No inhibition or enhancement of growth that could not be attributed to temperature changes could be demonstrated in studies of *E. coli* exposed at 1.7, 2.45, and 68 to 74 GHz. The effects of changing the substrate and the strain of bacteria are now being examined.

Isolated rat liver mitochondria have been irradiated with 2.45 GHz of radiation at power densities of 10 and 50 milliwatts per square centimeter (mW/cm^2) to determine if an effect could be detected on respiration and oxidative phosphorylation (ATP synthesis). No effect was found. The available exposure facilities however, dictated irradiation at

0.4°C, a temperature at which mitochondria are biochemically inactive. A coaxial airline exposure system is now being developed to allow exposure at 25°C or 37°C.

The possibility of interaction of microwave radiation with macromolecules has been examined using bovine serum albumin as the test material. Because transient effects can be most readily observed as the sample is being irradiated, a cross-beam apparatus consisting of a waveguide irradiation system integrated with the UV spectrophotometer used to detect structural changes has been developed. No significant effect was observed at 1.7 or 2.45 GHz.

An increase in the percentage of chromosome aberrations has been observed in kidney, lung, and thyroid cells cultured from Chinese hamsters irradiated with 2.45 GHz of radiation at a power density of 200 mW/cm^2 for varying times—and at 25, 50, 100, 150, and 200 mW/cm^2 for a constant time. The percentage of aberrations scored was dependent upon time of exposure but apparently not dependent upon power density. No dependence upon body temperature was observed.

The range of frequencies over which exposures can be made continues to expand. Ongoing research using a time domain reflectometer system is attempting to identify anomalous absorption characteristics of biological materials at specific frequencies. In any event, future work will ensure that FM, VHF TV, and UHF TV frequencies, as well as the S- and X-microwave bands, receive adequate coverage. These work areas along with an examination of potential teratologic and neurobiologic effects and non-ionizing radiation represent the major areas of effort in the immediate future.

Multiple, Coexisting Environmental Stressors

Standards for the protection of the public against toxic environmental agents do not usually consider the implications of the coexistence of multiple, potentially synergistic stressors. The Experimental Biology Laboratory's program has been limited to studies on interactions between two potentially synergistic pollutants from among the multitude of potentially toxic agents and combinations thereof in existence.

Evidence suggested that cadmium and whole body radiation may act synergistically upon the hematopoietic system. Coinsult studies in rats involving intraperitoneal injection of cadmium chloride and exposure to X-rays showed that the $LD_{50/30}$ values for 250 kVp X-rays decreased linearly with increasing amounts of cadmium from 695 rads (in animals receiving no cadmium) to 491 rads (in a group receiving 250 micrograms of cadmium chloride twice weekly for 30 days). Coinsults drastically altered the number of circulating red and white blood cells and significantly lowered the lymphocyte/neutrophil ratio for extended periods of time. Cadmium chloride definitely is a radiosensitizing agent and its biological effect is synergistic.

Currently underway is a study of the long-term effects of continuous exposure to lead and tritium, two pollutants possessing characteristics that suggest that they may act synergistically. Both are transplacentally transferred; the embryo and fetus are particularly sensitive to both, and exposure can result in reduced litter size, stunted new-borns, sterility, and mental retardation. Rats in EBL studies are being exposed to lead, tritiated water, and combinations of the two from conception, through the production of a new generation, to the adulthood of the F_2 generation. Lead levels of 5 to 50 ppm (100 and 1000 times the Public Health Service standards for drinking water, respectively) and tritium levels that are 2 to 200 times the standard (MPC_w) for individuals in the general population are used in the study. The F_1 generation is being observed for growth and for the development of reflexes and spontaneous motor activity. The F_2 generation will be examined for gross teratologic manifestations including pathology, and for postnatal development in terms of reflex development, spontaneous motor activity, coordination, learning, and social behavior.

Future plans call for studies of more complex exposure situations that can be expected to occur in the environment; for example, the neurobiologic consequences of simultaneous exposure to 60-Hz radiation, high frequency noise, and ozone, a condition found in the vicinity of high voltage electrical transmission lines.

Pesticides
and
Toxic
Substances
Effects
Laboratory

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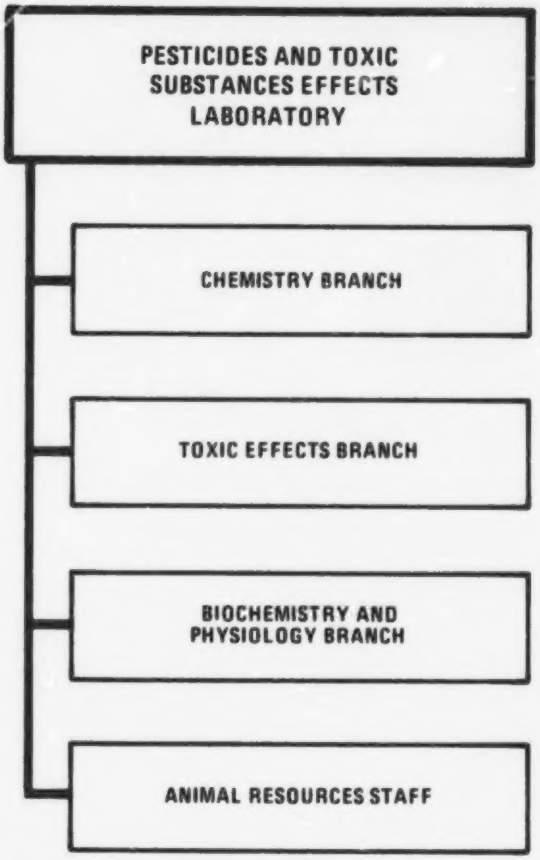
Pesticides and Toxic Substances Effects Laboratory


PESTICIDES AND TOXIC SUBSTANCES EFFECTS LABORATORY
CHEMISTRY BRANCH
TOXIC EFFECTS BRANCH
BIOCHEMISTRY AND PHYSIOLOGY BRANCH
ANIMAL RESOURCES STAFF

Studies to determine the effects of pesticides are conducted in the field using a self-contained, portable electroencephalograph. The EEG data are recorded on tape cassette for computer processing at the Pesticide and Toxic Substances Effects Laboratory.

OVERVIEW OF PTSEL'S MISSION

EPA's Office of Pesticide Programs is responsible for registering pesticides for use in the U.S. and for establishing tolerance levels of pesticide residues in or on raw agricultural products. All research conducted at NERC-RTP's Pesticides and Toxic Substances Effects Laboratory (PTSEL) is designed to provide a foundation for decisions made by EPA's registration offices. Data from acute, subacute, and chronic studies in laboratory animals and examinations of occupationally exposed individuals are used to augment the basic scientific knowledge that establishes the need for continued registration of pesticides or toxic substances in use in the U.S. Analytical chemistry research is directed toward the detection of toxicants in biological samples.

Included among the basic research goals and objectives of the PTSEL is the development, evaluation, and application of instrumental techniques in a program of basic and applied research in two general areas:

- Elucidation of the mechanism of action of pesticides and their metabolic products in a variety of biological substrates and in appropriate model systems. This research is accomplished through the use of magnetic resonance and spectrophotometric techniques.
- Development of a methodology and capability for the isolation, detection, characterization, identification, confirmation, and/or quantitation of pesticide residues, metabolites, and other chemical contaminants in human, animal, and environmental media. This research is accomplished, in part, through the use of magnetic and quadrupole resonance methods, spectrophotometric techniques (including infrared, ultraviolet, and atomic absorption), gas and liquid chromatography, and combinations of chromatographic separations with sensitive and specific detection systems and low- and high-resolution mass spectrometry.

Newer and more comprehensive analytical methods for the determination of residues of pesticides and their metabolic products are being developed to permit effective monitoring of the total environment. The continued development of analytical methods in pesticidal research is a necessary component of efforts to minimize human and animal exposure and to preserve the quality of the environment.

LEGISLATIVE MANDATE

Public law and policy and the traditions of many decades have directed governmental efforts to assure that the Nation's food supply is safe, clean, and wholesome. EPA, committed to full enforcement of these laws, has developed criteria and protocols for pesticides and toxic substances that are effective, workable, and enforceable. The wholesomeness of any food supply depends in part on the quality of the total environment: the soil, water, and air in which the food is grown, processed, and consumed. Contamination of these basic natural resources by pesticide residues and other pollutants can affect not only the safety of food products but also other environmental values such as water quality, wildlife preservation, and outdoor recreation. EPA is actively seeking to protect and manage these resources in the interest of greater human safety and welfare.

The statutory authority for the regulation of pesticides and pesticide residues delegates the responsibility for the registration of pest control materials to EPA. In addition, the establishment of tolerances for pesticides in or on human food and feed for animals has been delegated in part to EPA and in part to the Food and Drug Administration of the Department of Health, Education, and Welfare.

If the proposed use of a pesticide will result in residues on a food or feed crop, a registration for its use is granted provided a tolerance has been established by the regulatory authorities within EPA. The regulation of pesticide and pesticide residues by the Federal government encompasses those pesticides or residues involved in interstate commerce. Pesticides in food supplies produced and used within a State are under the jurisdiction of that State. The various Federal agencies work closely with their State counterparts in pesticide regulation and control, however.

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), enacted in 1947, regulates the marketing of economic poisons and devices. This act was amended in 1959, 1964, and more recently in 1972 to include the Federal Environmental Pest Controls Act (FEPCA).

The term "economic poison" is defined as any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating forms of plant and animal life (such as insects, rodents, fungi, and weeds) or viruses (except viruses on or in living humans or other animals) and any substance or mixture of substances intended for use as a plant regulator, defoliant, or dessicant. Under this act no pesticide chemical may be legally shipped in interstate commerce for general use until it is known to be safe when used as directed and effective for the purpose claimed on the label. Also, any residues that may remain in or on feed or food must not exceed the safe tolerance levels established under the Food, Drug, and Cosmetic Act (FDCA). FIFRA prohibits the shipment in interstate commerce of products that are not registered or are adulterated or misbranded. Products that are in violation of the Act may be seized and criminal action instituted against the shipper of such products. In the more recent amendment (FEPCA), in addition to directing labeling restrictions for pesticide registration, EPA is responsible for: prescribing standards for the certification of applicators of pesticides; administering the use permits system; registering pesticide producers including the examination of records and books and the inspection of plants; conducting research and monitoring activities including monitoring air, water, soil, humans, plants, and animals; and regulating pesticides imported to or exported from the country.

EPA's authority for the establishment of tolerances for pesticides in or on foodstuffs or raw agricultural products is provided by the Pesticide Chemical Amendment (PCA) of the FDCA. The paramount purpose of this Act is to assure the safety of the Nation's food supply. In part, this assurance is provided by ensuring that the residues remaining on the food are safe for consumption and by requiring government clearance before a pesticide is used. This Act further provides for seizure and destruction of agricultural commodities that contain pesticide residues in excess of established tolerances. Where no tolerance has been established, commodities carrying residues in excess of established working levels are also subject to seizure and destruction. This Act also provides both for criminal penalties for violation and for legal injunctions to halt use. The FDCA outlines the data and information to be furnished and the procedures to be followed for obtaining a pesticide tolerance. Additional procedures and more specific data requirements in the regulations ensure that food safety requirements are met prior to establishing a tolerance. As provided under Section 408 of the FDCA, tolerances are established for raw agricultural commodities, not for processed food. If the residues remaining in a processed food have been removed to the fullest extent possible through good manufacturing processes and do not exceed the tolerances on the raw product, the processed product complies with the law. In general, the residues in processed food are a fraction of the amount permitted on the raw agricultural product. To cover the residues of pesticides applied to or concentrated in processed foods, tolerances may be established under Section 409 of the Food Additives Amendment of the FDCA, administered by the Food and Drug Administration. Because the major use of pesticides in the U. S. is on raw agricultural commodities, the overwhelming majority of established tolerances are on these products. Ideally pesticide residue tolerances should apply to ready-to-eat food on the dinner plate because it is the quantity of pesticide actually consumed that has health significance; however, tolerances established at this point in the food chain would not be practical. Therefore, a point in the distribution system where meaningful, corrective action can be taken to prevent the consumption of unsafe amounts of pesticide chemicals has been selected. The tolerance concept does not anticipate, as a practical matter, that all foods will contain residues of all chemicals as high as the established tolerance level, or even that all of a single food will always contain a residue at the tolerance level.

Within the framework of registration of pesticides and of establishment of a tolerance for pesticides, several considerations must be advanced: the registered use and the tolerance level must be safe for the applicator, the consumer, and the environment; the level of residue must be safe if all of a particular raw food containing residues at the tolerance level is always consumed, the tolerance will not reflect the average residue on a commodity but will represent the maximum residue that will remain under good agricultural practice; the tolerance generally is established on raw agricultural commodities and does not realistically reflect the residue in or on food as eaten; and the tolerance will be set only at levels reasonably required to cover the residue likely to occur as a result of good agricultural practice. In the regulation of pesticides EPA's policy is to minimize the exposure of the consumer and the environment to pesticides and their residues in the interest of safety and reduced environmental contamination.

To register a pesticide and to establish tolerances for the pesticide in or on raw agricultural commodities, toxicity tests on the proposed material must be conducted to show that the directed use of the product would not be injurious to humans, other animals, or the ecological system when warnings and cautions are carefully heeded. The extent of toxicological data required to fulfill these requirements varies with the nature and proposed use of the product. Biological tests under field and laboratory conditions must be conducted to determine if the product will control the pests named on the label when used as directed without causing a significant adverse effect to the crop or the property being treated. The basic requirement for registering pesticide chemicals and establishing tolerances is that the data and other information, when evaluated as a whole, will establish the safety of the proposed pesticide usage. This judgment is made by personnel qualified by training and experience to evaluate the safety of pesticide residues in or on food. In addition to toxicological requirements, suitable methods of analysis must be available for monitoring and enforcing the proposed registration. Sensitivity, accuracy, and precision in available analytical methods must be evaluated in relation to the proposed use and toxicity of the pesticide chemical. Extraction and clean-up procedures must efficiently remove and recover residues from treated samples from suspected cases of contamination.

Data requirements for registration and for the establishment of tolerances are subject to continual review in light of new scientific data and information. Specifically, advances in scientific knowledge are continually evaluated to provide the necessary criteria for the conclusions made concerning the safety of pesticides

Table 10 is a summary of the resources employed by PTSEL for Fiscal Year 1974 under the Federal Environmental Pesticide Control Act of 1972, Section 20.

Table 10. SUMMARY OF RESOURCES FOR PESTICIDES AND TOXIC SUBSTANCES EFFECTS LABORATORY FOR FISCAL YEAR 1974

(Federal Environmental Pesticide Control Act of 1972[a]–Section 20)

Category	Funds, $\$10^3$	Positions	Approximate percent
Pesticides health effects research	1539	51	49
Pesticide identification methodology	335	11	11
Toxic substances health effect research	180	7	6
Quality assurance	257	10	8
Substitute pesticides program	830	12	26
Totals	3141	91	100

[a]Includes Federal Insecticide, Fungicide, and Rodenticide Act.

ORGANIZATION

The Pesticides and Toxic Substances Effects Laboratory consists of two main functioning laboratory groups: biological and physical.

Physical research is conducted by the Chemistry Branch, which is responsible both for the study of the metabolism of pesticides, their metabolites, and residual products in a variety of biological and environmental substrates and for the development of methodology for the determination of pesticide residues. In addition, quality assurance for methods used by EPA and other laboratories is maintained through the use of a standard reference repository and an instrumental workshop for maintenance of equipment.

Biological research is conducted in two branches: the Toxic Effects Branch and the Biochemistry and Physiology Branch. The Toxic Effects Branch is responsible for investigating short- and long-term effects (including reproductive hazards) of pesticides. Teratogenesis and mutagenesis potentials of pesticides are principally addressed in this area as are acute, subacute, and chronic studies on laboratory animals. Complete pathological facilities are available for examination of tissues and organs of test subjects. The Biochemistry and Physiology Branch predominantly investigates the mode of action of pesticides on a cellular and subcellular basis using laboratory animals. Epidemiological investigations on occupationally exposed workers are carried out in the Branch's Field Studies Section located at Wenatchee, Washington. Field investigations on the biological effects of pesticides and toxic substances are also carried out at Wenatchee. The Animal Resource Facility maintains the animal quarters for the entire NERC-RTP. Small laboratory animals, primates, and selected unusual experimental animals (e.g., voles) are maintained for use in pesticide and toxic substances research.

Effects of pesticides and toxic substances are studied using laboratory animals.

Test dose of pesticide is administered to pregnant rat using intubation technique.

The basic purposes of these facilities are to maintain both a level of applied research in EPA's areas of responsibility and the means to respond to high priority problems. The maintenance of several fundamental areas of investigation allows the scientists to respond quickly to inquiries either through personal experience or by initiating programs to resolve the issues.

PHYSICAL FACILITIES

The physical facilities of the Pesticides and Toxic Substances Effects Laboratory, located both at NERC-RTP and in Wenatchee, are superior to most laboratories of comparable size and function. These facilities provide instruments for magnetic resonance studies using spectrophotometry, for atomic absorption studies, for mass analysis studies, and for combinations of chromatographic and mass spectroscopy techniques with integrated computer analysis for efficient, reliable analysis of pesticide residues. To maintain the sophisticated electronic instruments, a maintenance group provides repair and modification services to the laboratory, to EPA pesticide contract laboratories, to other Federal and State facilities, to the World Health Organization, and to research laboratories of foreign governments. The PTSEL

Teratogenic effects of pesticides are studied through fetal necropsy.

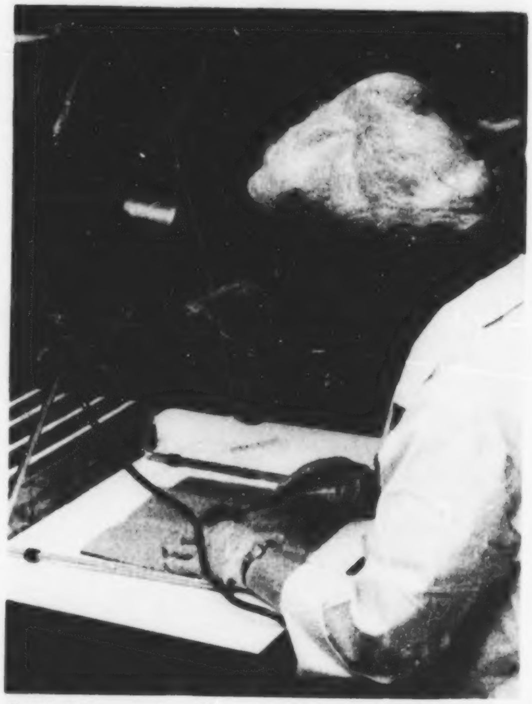
repository, containing approximately 450 standard reference pesticides, provides high-grade analytical standards for U.S. and foreign laboratories conducting a wide variety of studies. To support biological studies, radioactivity tracer equipment for measurement of low- and high-energy emitters is available. Complete facilities are available for the preparation and analysis of radioactive samples.

MAJOR PROGRAM AREAS

Health effects research on pesticides, toxic substances, and their residues includes. establishing the chemical identity of residues, with emphasis on significant conversion products; developing, improving, and validating residue measurement methodology; and conducting a biological research program aimed at evaluating the hazards of pesticides and their residues and conversion products by acquiring information on the effects of these materials on animals and (ultimately) on humans.

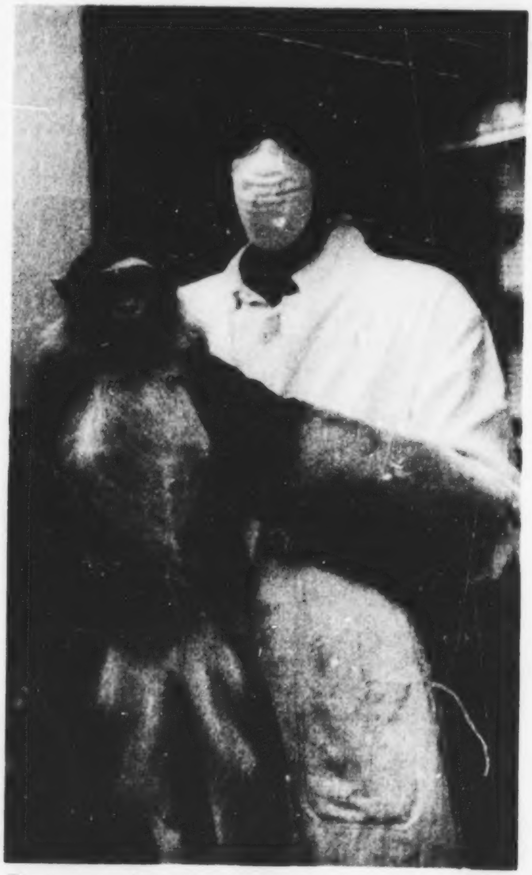
Pesticide Identification Methodology

The development of adequate methodology for the analysis of pesticides and their residues is a continuing problem requiring continual upgrading as new pesticides are introduced or usage patterns change. Multiple-residue techniques that will detect many pesticides simultaneously have simplified the regulatory analytical problems; but, they have also greatly complicated research and development programs. It is often difficult to fit a pesticide into a multiple-residue detection scheme without complicating the scheme with the pesticides for which it was originally developed. A large group of pesticides coming into increasing use is the anticholinesterase agents, that is, the carbamates and organophosphates. These agents are just now being fitted into such multiple-residue techniques. Furthermore, multiple-residue detection techniques alone do not establish unequivocally the identity of the pesticide residue, particularly if artifacts or interferences are encountered. Identity of the residue must be confirmed by other methods, and a variety of such confirmatory methods must be available for the many different pesticides in use.



Pesticide-caused malformations in rat fetus are often revealed through tissue magnification.

In addition to the adaptation of present methods to new chemicals and the development of new methods, improvements in the sensitivity, efficiency, rapidity, and simplicity of existing methods are needed to improve the effectiveness of a monitoring program. A quality control manual for pesticide monitoring is being developed to assure the proper analytical control of the use of pesticides. This analytical manual incorporates collaboratively tested methods for determining pesticides and other chemical residues in air, water, and food; in human and animal tissues; and in other environmental media. At the present time this manual has been prepared for a limited number of substrates and pesticide compounds; it is continually being upgraded. New and or improved analytical methods and detection systems for pesticides are being developed and published continually. Certain of these methods show promise regarding their suitability for analysis of substrates relating to humans and the environment and are being evaluated for inclusion into the analytical quality control manual.



Electroencephalogram changes have occurred in laboratory monkeys after long-term, low-level exposure to some pesticide.

In an effort to establish the identity of a residue in the presence of interfering materials, confirmatory methods such as mass spectrometry are being utilized. A high resolution mass spectroscopy laboratory has begun operation, and new methods for determining trace metals in human tissues and excreta that combine mass spectroscopy with other analytical tools including gas chromatography and atomic absorption have been developed. Through the application of gas-chromatography/mass-spectroscopy techniques, various pesticides have been identified in human tissues, including Mirex, Oxychlordane, HCB, Nonaclor, and other chlorinated pesticides and contaminants such as polychlorinated biphenyls.

Current methodology for determining pesticides in air is inadequate both for sampling and for identification purposes. Studies are currently in progress to correct this situation by amplifying the sampling phase of the methodology. A new trapping system for the further determination of pesticides in air samples has been laboratory tested and is being examined in the field.

Improved methodology for the determination of low-level organo-phosphate exposure in humans has been developed and is currently being field tested in occupationally exposed and normal populations. The urinary alkylphosphate method has been shown to be sensitive and reproducible for the determination of low-level exposure in humans and is expected to be a welcome addition to the analytical methodology currently available for defining such exposure.

Environmental samples (e.g., human tissues, wildlife, plants, and water) of dioxin contamination of range land and other areas from 2,4,5-T exposure have been analyzed to assure that this environmental contaminant has not been introduced to the U.S. through the normal use of herbicides.

In many cases, residue from the use of a pesticide comprises not only the chemical applied but also toxic degradation or other conversion products that may be formed on exposure to light and weathering. Metabolic products may be formed in animals and deposited in edible tissues or milk. This phase of the research program ensures that the composition of residues has been established and that the analytical methodology developed will measure all toxicologically significant residual chemicals. Metabolic studies of chlorinated pesticides have established the occurrence of a series of metabolites of the pesticide Lindane for which analytical methodology is currently being developed. The occurrence of these metabolites of Lindane, formed in the liver by the drug metabolizing system, forms the basis of an *in vitro* screening procedure for examining the biological effects of pesticides and other exogenous materials on drug metabolizing enzymes.

Quality Assurance

A quality control program currently in operation includes: the calibration and upgrading of instrumentation, the standardization and distribution of materials for the determinative and clean-up steps in pesticide analyses, the distribution of standard reference material for use in quality control, and the evaluation of laboratory procedures and performances on standard reference materials. This program continually upgrades methodology and laboratory capability in the 15 U.S. laboratories involved in the study of health effects of pesticides. Each year, over 3000 analytical standards are shipped to approximately 420 laboratories around the world. All EPA laboratories routinely draw samples from a repository of standard reference materials for pesticide measurement that includes over 400 currently available analytical standards.

Quality control studies for clinical biochemistry and pesticide analytical determinations to assure reproducibility in data from various laboratories and various sections of the country give assurance that analytical methodology will be available to measure all toxicologically significant pesticides and that variations will be minimal.

Health Effects of Pesticides and Toxic Substances

PTSEL's biological research program is directed toward evaluating the hazard of pesticide residues and their conversion products by acquiring information on the effects of these materials on animals and (ultimately) on humans. This applied research is directed to establishing the safety of pesticides and developing the scientific foundation for EPA pesticide policies. The research effort includes: development of data on new types of pesticides to facilitate EPA guidance of commercial work, more detailed examination of specific toxicological effects for their impact on safety evaluations, examination and development of new toxicological methods for evaluating product safety, and resolution of conflicting or equivocal data for a sounder evaluation of the safety of pesticides and their residues. With this information, environmentally safe pesticides can be registered, and safe tolerance levels and reliable enforcement policies can be established. In all cases, animal experimentation should produce measurable parameters that can be used for logical prediction of toxicity in humans. It is highly desirable to determine how toxic substances affect humans so that an animal species that will provide corresponding data useful in the safety interpretation can be obtained.

In brief, EPA's health effects research includes studies of the physiological and metabolic effects of pesticides in biological systems including: the metabolic fate of the compounds and their biochemical reactions, the nature of the metabolic pathways and an evaluation of their effects in terms of toxic action, and the development of data on the direct effect of pesticides on humans. In this regard, previous primate studies on the effect of carbaryl, a carbamate insecticide, have shown that the EEG is a sensitive tool for measuring biological effects. The effect of several pesticides on EEG parameters in squirrel monkeys was investigated and several points of interest emerged: the magnitude of alteration of the EEG did not correlate with the relative toxicity of the compound, similar EEG alterations were induced by chemically unrelated compounds, and carbaryl was effective in altering the EEG of squirrel monkeys at a dose that approximates the incidental or background exposure levels in humans. This low-level exposure to carbaryl was also responsible for certain changes in animal behavior. To correlate these effects and to determine if they can be duplicated in humans, portable EEG units were constructed and are being field tested in studies of people who are occupationally or incidentally exposed to pesticides.

The delayed neurotoxic demyelinating potential of several organophosphate pesticides was examined in animals. High concentrations of an experimental organophosphate insecticide were found to induce demyelination in the central and peripheral nervous systems causing irreversible paralysis in the animals. The significance of this unusual effect from a potentially commercial organophosphate pesticide is being further investigated to determine its significance to humans with regard to occupational exposure and ingestion of residues in food.

In a further effort to examine the physiological effect of pesticides, the impact of several chlorinated pesticides and contaminants on reproduction was examined in laboratory animals. Studies of the teratological significance of exposure to dieldrin, Mirex, photodieldrin, dioxin (several different isomers), and 2,4,5-T were evaluated. In addition, *in vivo* and *in vitro* screening techniques were developed for the evaluation of both the neurotoxicity and the biological effects of pesticides on liver function. These techniques have been useful in the screening of new pesticides prior to the initiation of long-term studies to evaluate their toxicological significance.

Extramural Program

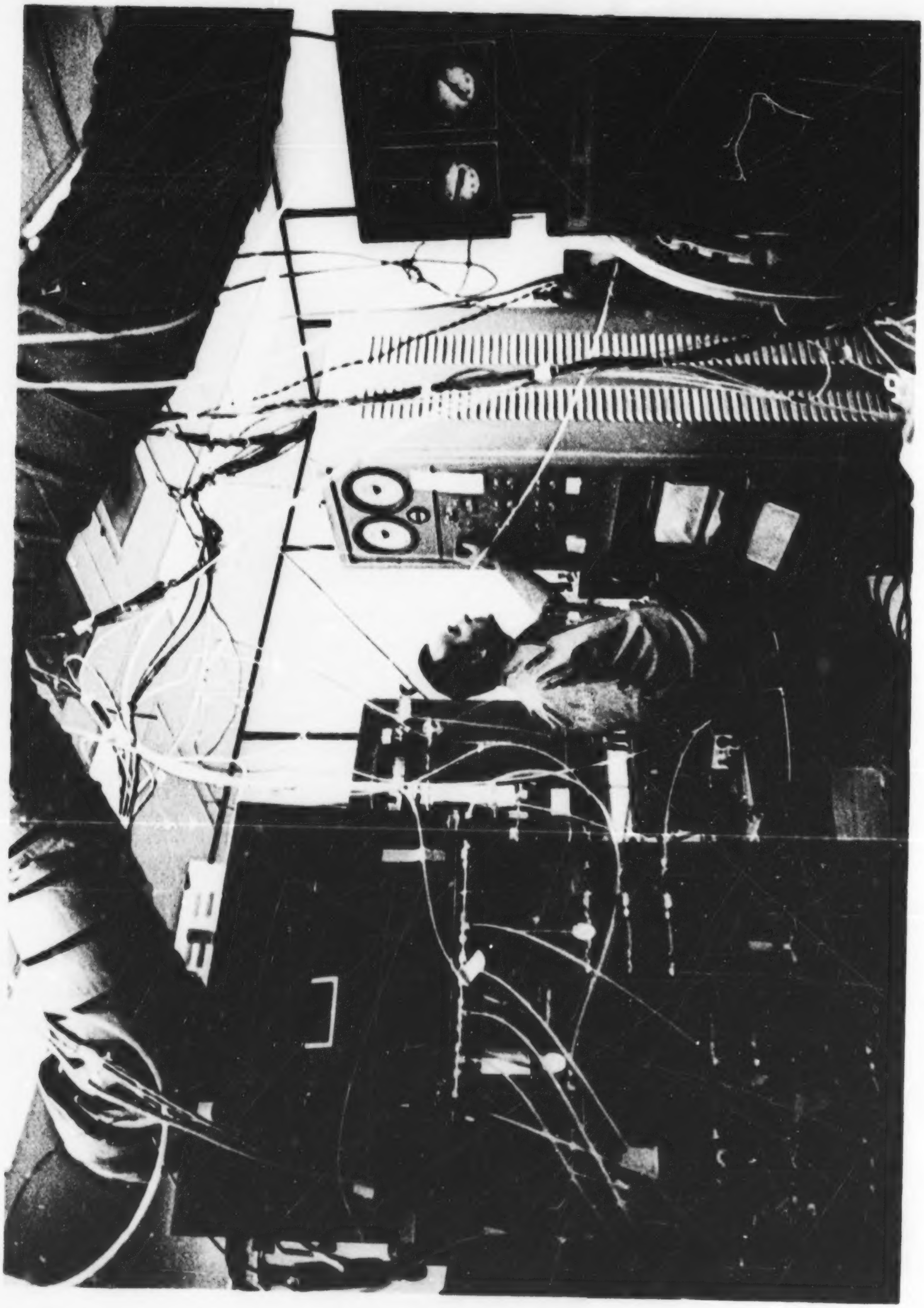
The extramural research grant and contract program authorized in part by FIFRA and in part by the

Public Health Service Act continues to support pesticide research activity at universities and non-profit research organizations. The following program titles indicate areas of extramural study that provide data to augment PTSEL's research supporting the regulatory activity of EPA:

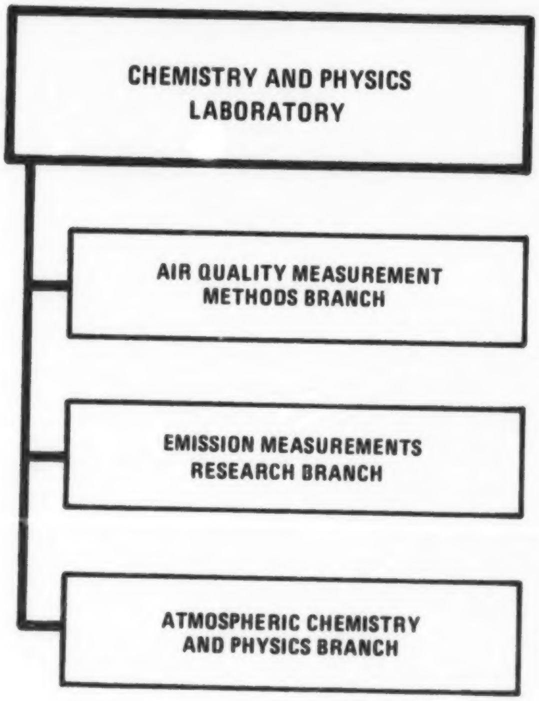
- Mode of Action of Cyclodiene Insecticides–University of Arizona
- Metabolic Interactions of Hormonal Steroids and Chlorinate Hydrocarbons–University of Michigan
- Mechanisms of Pesticide Degradation–University of Wisconsin
- The Study of the Ecology of Pesticides-University of Miami
- Actions of Pesticides and Other Drugs on Male Reproductive Organs–West Virginia University Medical Center
- Effect of Duck Hepatitis Virus on Pesticide Toxicity–University of Georgia
- Chemistry and Mode of Action of Insecticides–University of California (Riverside)
- Biological Hazards of Phototransformed Pesticides Stanford Research Institute
- Metabolism of Carbamate Insecticides–University of Kentucky
- Role of Mixed Function Oxidases in Insecticide Action–University of Illinois
- Pesticide Epidemiological Field Studies–University of Miami
- N.M.R. Studies on the Molecular Interactions of Pesticide of Environmental Concern–Oregon State University
- Investigation of Pesticides in Human Milk–Meharry Medical College
- Sensitive Specific Fluorescence Immunoassay Methods for Detecting Organic Contaminants–IntelCom-RadTech
- Analysis of Clinical Specimens–University of Miami

Because PTSEL was recently relocated from Florida to North Carolina, accomplishments outlined in this report effectively cover only the period of January through September 1973; except for the extramural program, which was consistent over the entire year.

Chemistry
and
Physics
Laboratory



Chemistry and Physics Laboratory


CHEMISTRY AND PHYSICS LABORATORY
AIR QUALITY MEASUREMENT METHODS BRANCH
EMISSION MEASUREMENTS RESEARCH BRANCH
ATMOSPHERIC CHEMISTRY AND PHYSICS BRANCH

Studies, including simulations, of photochemical air pollution are conducted using environmental chambers and high sensitivity instrumentation at the Chemistry and Physics Laboratory.

Chemistry and Physics Laboratory

OVERVIEW OF CPL'S MISSION

NERC-RTP's Chemistry and Physics Laboratory (CPL) manages and conducts an intramural and extramural research program that provides (1) techniques and instrumentation for the measurement of atmospheric pollutants, (2) information on the chemical and physical transformations that pollutants undergo in the atmosphere, and (3) information on the effects of atmospheric pollutants on materials. While each of these program areas contributes directly to the air pollution control program, all are also closely interrelated: air pollution measurement techniques and instrumentation research support atmospheric chemistry and physics studies; atmospheric chemistry and physics studies provide information on what measurement techniques are needed; and studies of the effects of atmospheric pollutants on materials provide information on mechanisms whereby pollutants can be removed from the atmosphere.

LEGISLATIVE MANDATE

The program of the Chemistry and Physics Laboratory is totally responsive to the legislative mandates of the Clean Air Act of 1970. The research and development program relates to many of the sections of the Act as specifically detailed below.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **"Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution and as part of such program shall—**
>
> **"(1) conduct, and promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, and control of air pollution; . . .**
>
> **"(3) conduct investigations and research and make surveys concerning any specific problem of air pollution in cooperation with any air pollution control agency with a view to recommending a solution of such problem, if he is requested to do so by such agency or if, in his judgment, such problem may affect any community or communities in a State other than that in which the source of the matter causing or contributing to the pollution is located;"**

Each year the Chemistry and Physics Laboratory conducts one or more field studies of air pollution. During 1973 a field study was conducted in Denver, Colorado, in cooperation with the EPA Regional Office and the State air pollution control agency. The study was part of a continuing effort to determine the nature and source of the Denver "Brown Cloud."

Field studies were also conducted in Houston, Texas, and Phoenix, Arizona, on photochemical oxidant, and in St. Louis, Missouri, on photochemical oxidant and sulfur oxides air pollution.

Analysis of the data for the Denver field study indicated that the "Brown Cloud" is a two-component plume: one part, close to the ground, contains major amounts of aerosol from stationary sources; and a second part, above the first, contains aerosol largely from automotive sources.

> **"(4) establish technical advisory committees composed of recognized experts in various aspects of air pollution to assist in the examination and evaluation of research progress and proposals and to avoid duplication of research . . . ."**

The Chemistry and Physics Laboratory provides administrative management of the Air Pollution Chemistry and Physics Advisory Committee. The Committee met twice in 1973: first in St. Louis, where the principal agenda item was the Regional Air Pollution Study (RAPS) in progress there; and second at the University of Minnesota, where the main subject was atmospheric aerosols.

> **"(f) (1) In carrying out research pursuant to this Act, the Administrator shall give special emphasis to research on the short- and long-term effects of air pollutants on public health and welfare. In the furtherance of such research, he shall conduct an accelerated research program . . .**
>
> **"(B) to improve knowledge of the short- and long-term effects of air pollutants on welfare."**

Research on the effects of air pollutants on materials and on atmospheric visibility is part of the program of the Chemistry and Physics Laboratory. In 1973 an experiment was begun in which several critical materials are exposed to simulated polluted atmospheres in chambers. The first phase of this work will be completed in 1974 and will eventually provide quantitative dose/response information.

> **"RESEARCH RELATING TO FUELS AND VEHICLES**
>
> **"Sec. 104. (a) The Administrator shall give special emphasis to research and development into new and improved methods, having industrywide application, for the prevention and control of air pollution resulting from the combustion of fuels . . .**
>
> **"(b) In carrying out the provisions of the section, the Administrator may—**
>
> **"(1) conduct and accelerate research and development of low-cost instrumentation techniques to facilitate determination of quantity and quality of air pollutant emissions, including, but not limited to, automotive emissions; . . .**
>
> **"(3) establish and operate necessary facilities and test sites at which to carry on the research, testing, development, and programming necessary to effectuate the purposes of this section; . . . ."**

In 1973 the Chemistry and Physics Laboratory developed specialized gas chromatographic instrumentation to measure "reactive" hydrocarbons in automotive exhaust. This equipment was put into use in EPA's Mobile Source Pollution Control Laboratory in Ann Arbor, Michigan. Also in 1973, work was started on additional engine dynamometers and a stationary source simulator to increase the facilities which support research to develop instrumentation and techniques to measure pollutants emitted by these sources.

> **"AIR QUALITY CRITERIA AND CONTROL TECHNIQUES**
>
> **"Sec. 108. (a) (1) For the purpose of establishing national primary and secondary ambient air quality standards . . .**
>
> **"(2) The Administrator shall issue air quality criteria for an air pollutant within 12 months after he has included such pollutant in a list under paragraph (1). Air quality criteria for an air pollutant shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of such pollutant in the ambient air, in varying quantities. The criteria for an air pollutant, to the extent practicable, shall include information on—**
>
> **"(A) those variable factors (including atmospheric conditions) which of themselves or in combination with other factors may alter the effects on public health or welfare of such air pollutant;**
>
> **"(B) the types of air pollutants which, when present in the atmosphere, may interact with such pollutant to produce an adverse effect on public health or welfare; and**
>
> **"(C) any known or anticipated adverse effects on welfare . . .**
>
> **"(c) The Administrator shall from time to time review, and as appropriate, modify, and reissue any criteria or information on control techniques issued pursuant to this section . . . ."**

CPL initiated a program on analytical methods and instruments to be used as portable analyzers (dosimeters) in health studies to aid in revision of air quality criteria. Effects of air pollutants on organic and inorganic materials are investigated in environmental chambers to supply input to development or modification of secondary standards for the criteria pollutants. Research on new particulate mass monitoring instrumentation is in progress to provide a more acceptable reference or equivalent method for total suspended particulates. Considerable effort is going into the development of the measurement technology for fine particles and for other pollutants that may be considered candidates for air quality criteria. The formation and decay of such non-criteria pollutants also are under investigation.

> **"NATIONAL AMBIENT AIR QUALITY STANDARDS**
>
> **"Sec. 109. (a) (1) The Administrator—**
>
> **"(A) within 30 days after the date of enactment of the**

> **Clean Air Amendments of 1970, shall publish proposed regulations prescribing a national primary ambient air quality standard and a national secondary ambient air quality standard for each air pollutant for which air quality criteria have been issued prior to such date of enactment; and**
>
> **"(B) after a reasonable time for interested persons to submit written comments thereon (but no later than 90 days after the initial publication of such proposed standards) shall by regulation promulgate such proposed national primary and secondary ambient air quality standards with such modifications as he deems appropriate . . .**
>
> **"(b) (1) . . . Such primary standards may be revised in the same manner as promulgated."**

Considerable efforts in support of present national ambient air quality standards (particularly those for hydrocarbon/oxidants and nitrogen dioxide) are in progress in CPL to further define the atmospheric relationships involving hydrocarbons and oxidants. Evaluation of the reference method for nitrogen dioxide was made, and the 24-hour average colorimetric method was improved; continuous instrumentation was also developed.

> **"IMPLEMENTATION PLANS**
>
> **"Sec. 110. (a) (1) Each State shall, after reasonable notice and public hearings, adopt and submit to the Administrator, within nine months after the promulgation of a national primary ambient air quality standard (or any revision thereof) under section 109 for any air pollutant, a plan which provides for implementation, maintenance, and enforcement of such primary standard in each air quality control region (or portion thereof) within such State. In addition, such State shall adopt and submit to the Administrator (either as a part of a plan submitted under the preceding sentence or separately) within nine months after the promulgation of a national ambient air quality secondary standard (or revision thereof), a plan which provides for implementation, maintenance, and enforcement of such secondary standard in each air quality control region (or portion thereof) within such State. Unless a separate public hearing is provided, each State shall consider its plan implementing such secondary standard at the hearing required by the first sentence of this paragraph."**

CPL is involved in a considerable effort to support development of chemical and physical air pollution models for reactive pollutants for use in implementation plans, including site criteria of large area sources. The transport of oxidants and the rural oxidant problem are under investigation. Empirical relationships between hydrocarbons and oxidants (such as upper limit curves) and relationships between hydrocarbons and nitrogen dioxide are being reviewed and evaluated. Reactivities of hydrocarbons and other organics have been evaluated for organic solvent regulations and transportation plans.

> **"STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES**
>
> **"Sec. 111. (b) (1) Within 120 days after the inclusion of a category of stationary sources in a list under subparagraph (A), the Administrator shall publish proposed regulations, establishing Federal standards of performance for new sources within such category. The Administrator shall afford interested persons an opportunity for written comment on such proposed regulations. After considering such comments, he shall promulgate, within 90 days after such publication, such standards with such modifications as he deems appropriate. The Administrator may, from time to time, revise such standards following the procedure required by this subsection for promulgation of such standards. Standards of performance or revision thereof shall become effective upon promulgation."**

Extensive support is provided by CPL in verifying and improving the reference methods for Category I and II new source performance standards. Performance criteria have been developed for extractive and in-situ instrumentation for determination of compliance with sulfur oxide, nitrogen oxide, and opacity standards for a number of the Category I sources. Methods development continues on the reference methods required for Category III, IV, and V new source performance standards.

> **"NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS**
>
> **"Sec. 112. (b) (1) (B) Within 180 days after the inclusion of any air pollutant in such list, the Administrator shall publish proposed regulations establishing emission standards for such pollutant together with a notice of a public hearing within thirty days. Not later than 180 days after such publication, the Administrator shall prescribe an emission standard for such pollutant, unless he finds, on the basis of information presented at such hearings, that such pollutant clearly is not a hazardous air pollutant. The Administrator shall establish any such standard at the level which in his judgment provides an ample margin of safety to protect the public health from such hazardous air pollutant."**

CPL is responsible for developing the analytical methodology for the national emission standards for hazardous pollutants. Improved methods of sampling and analysis are under investigation or evaluation for asbestos and mercury. There has been extensive development of X-ray flourescent methods for use in analyzing a number of elements possibly having a hazardous nature. Improved sampling and more rapid analysis methods for polycyclic organic matter are under development.

> **"PART A – MOTOR VEHICLE EMISSION AND FUEL STANDARDS**
>
> **"Sec. 202. (a) Except as otherwise provided in subsection (b)–**
>
> **"(1) The Administrator shall by regulation prescribe (and from time to time revise) in accordance**

> with the provisions of this section, standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles or new motor vehicle engines, which in his judgment causes or contributes to, or is likely to cause or to contribute to, air pollution which endangers the public health or welfare . . .
>
> "(b) (2) Emission standards under paragraph (1), and measurement techniques on which such standards are based (if not promulgated prior to the date of enactment of the Clean Air Amendments of 1970), shall be prescribed by regulation within 180 days after such date.
>
> "(e) In the event a new power source or propulsion system for new motor vehicles or new motor vehicle engines is submitted for certification pursuant to section 206 (a), the Administrator may postpone certification until he has prescribed standards for any air pollutants emitted by such vehicle or engine which cause or contribute to, or are likely to cause or contribute to, air pollution which endangers the public health or welfare but for which standards have not been prescribed under subsection (a)."

Measurement technology is being developed and evaluated for regulated and non-regulated emissions from on-the-road vehicles and advanced power sources. Improved optical-measurement instrumentation has been developed for the regulated pollutants. Measurement techniques were developed to support a reactivity type hydrocarbon standard if undertaken. Extensive research has been done on sampling techniques for particulate emissions from light-duty vehicles operated on leaded and non-leaded fuels using test vehicles with and without catalytic devices.

> "REGULATION OF FUELS
>
> "Sec. 211. (b) (2) For the purpose of registration of fuels and fuel additives, the Administrator may also require the manufacturer of any fuel or fuel additive—
>
> "(B) to furnish the description of any analytical technique that can be used to detect and measure any additive in such fuel, the recommended range of concentration of such additive, and the recommended purpose-in-use of such additive, and such other information as is reasonable and necessary to determine the emissions resulting from the use of the fuel or additive contained in such fuel, the effect of such fuel or additive on the emission control performance of any vehicle or vehicle engine, or the extent to which such emissions affect the public health or welfare . . .
>
> Tests under subparagraph (A) shall be conducted in conformity with test procedures and protocols established by the Administrator. The result of such tests shall not be considered confidential.
>
> "(c) (1) The Administrator may, from time to time on the basis of information obtained under subsection (b) of this section or other information available to him, by regulation, control or prohibit the manufacture, introduction into commerce, offering for sale, or sale of any fuel additive for use in a motor vehicle or motor vehicle engine (A) if any emission products of such fuel or fuel additive will endanger the public health or welfare, or (B) if emission products of such fuel or fuel additive will impair to a significant degree the performance of any emission control device or system which is in general use, or which the Administrator finds has been developed to a point where in a reasonable time it would be in general use were such regulation to be promulgated.
>
> "(2) (C) No fuel or fuel additive may be prohibited by the Administrator under paragraph (1) unless he finds, and publishes such finding, that in his judgment such prohibition will not cause the use of any other fuel or fuel additive which will produce emissions which will endanger the public health or welfare to the same or greater degree than the use of the fuel or fuel additive proposed to be prohibited."

CPL provides support in development of emission protocols for fuel additives effects. CPL also performs the emission characterization of non-regulated emissions from advanced alternate power systems. In 1973 nonregulated emissions from advanced alternate power systems were investigated. In 1973 considerable work was done on the problem of sulfate formation by exhaust oxidation catalyst systems. Work was begun on alternate automotive power systems such as the Wankel engine and the passenger vehicle diesel engine.

> "ADDITIONAL REPORTS TO CONGRESS
>
> "Sec. 313. Not later than six months after the effective date of this section and not later than January 10 of each calendar year beginning after such date, the Administrator shall report to Congress on measures taken toward implementing the purpose and intent of this Act including, but not limited to, (1) the progress and problems associated with control of automotive exhaust emissions and the research efforts related thereto; (2) the development of air quality criteria and recommended emission control requirements; (3) the status of State ambient air standards setting, including such plans for implementation and enforcement as have been developed; (5) the extent of development and expansion of air pollution monitoring systems; (6) progress and problems related to development of new and improved control techniques; (7) the development of quantitative and qualitative instrumentation to monitor emissions and air quality, (8) standards set or under consideration pursuant to title II of this Act; (9) the status of State, interstate, and local pollution control programs established pursuant to and assisted by this Act; and (10) the reports and recommendations made by the President's Air Quality Advisory Board."

Technical support is provided by CPL in development of air quality criteria documents and progress reports required by Congress on air quality, emission instrumentation, and emission standards for moving vehicles.

Table 11 contains a summary of resources employed by CPL for Fiscal Year 1974 in support of applicable sections of the Clean Air Act.

Table 11. SUMMARY OF RESOURCES FOR CHEMISTRY AND PHYSICS LABORATORY FOR FISCAL YEAR 1974

Section of Clean Air Act supported	Funds, 10^3	Positions	Approximate percent
103	536	5	6
108	1587	22.5	18
109	562	9.1	6
110	2393	12.5	28
111	1847	17.2	21
112	330	5.1	4
202	636	13.5	7
211	780	5	9
313	59	2.1	1
Total[a]	8730	92	100

[a]Does not include $0.5 million of special energy appropriations.

ORGANIZATION

The Chemistry and Physics Laboratory is organized into three branches. One of these deals with the problems of the physical and chemical transformations of pollutants in the atmosphere, and the other two are concerned with the development of techniques and instrumentation for the measurement of air pollution. All three branches are involved in both laboratory and field research and implement their programs through in-house projects and extramural research grants and contracts.

Atmospheric Chemistry and Physics Branch

The program of the Atmospheric Chemistry and and Physics Branch involves both laboratory and field studies. Laboratory studies are conducted in clean glass chambers with synthetic mixtures and in large irradiation chambers with real mixtures such as motor vehicle exhaust. Hypotheses developed in these laboratory studies are tested in the field by analysis of the atmosphere at critical sites chosen on the basis of the pollution sources, meteorology, and topography of the area. All of this information is used to choose appropriate air pollution strategies as well as to develop mathematical models of atmospheric photochemical reactions. Although the atmospheric chemistry and physics program previously concentrated on atmospheric reactions of gaseous pollutants such as are involved in the formation of ozone, research now includes studies of atmospheric reactions involving aerosols. The Branch also conducts research to determine the effects of environmental pollutants on materials. These capabilities in atmospheric chemistry are used in the Laboratory's participation in the Regional Air Pollution Study (RAPS) and in the Fuel and Fuel Additive Registration Program.

Air Quality Measurement Methods Branch

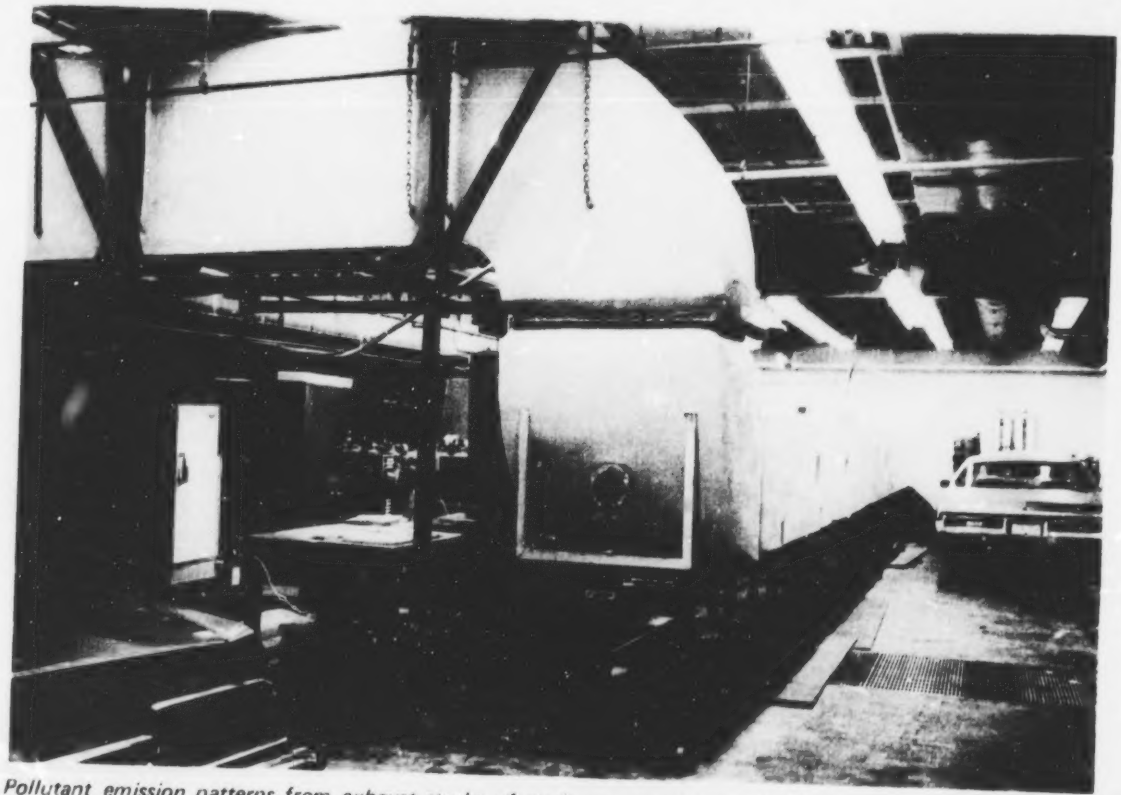
The Air Quality Measurement Methods Branch conducts research operations providing EPA with the capability of assessing environmental quality. This research is designed to produce and evaluate new and improved techniques for the identification and quantification of contaminants in the environment for field and laboratory use. The Branch develops instruments for performing continuous or periodic monitoring of the environment with minimal human attendance, and develops sensor systems for air quality measurement of pollutants in ambient air. Staff personnel provide methods for the analytical extraction of contaminants from the environment and for the qualitative and quantitative analysis of said contaminants after transport to the laboratory.

Emission Measurements Research Branch

The Emission Measurements Research Branch conducts research and development activities to provide analytical techniques and instruments for the identification and precise measurement of environmental pollutants in emissions discharged from all types of sources, both mobile and stationary. These activities are carried out primarily to support the implementation of national emission standards for mobile sources, performance standards for new stationary sources, and national emission standards for hazardous air pollutants as required under the provisions of the Clean Air Act of 1970. This Branch also conducts studies for the chemical and physical characterization of pollutants emitted from various sources.

PHYSICAL FACILITIES

A research prototype lidar system, designed specifically for particulate emission measurements from stationary sources, is housed in a mobile van to facilitate field studies now in progress.

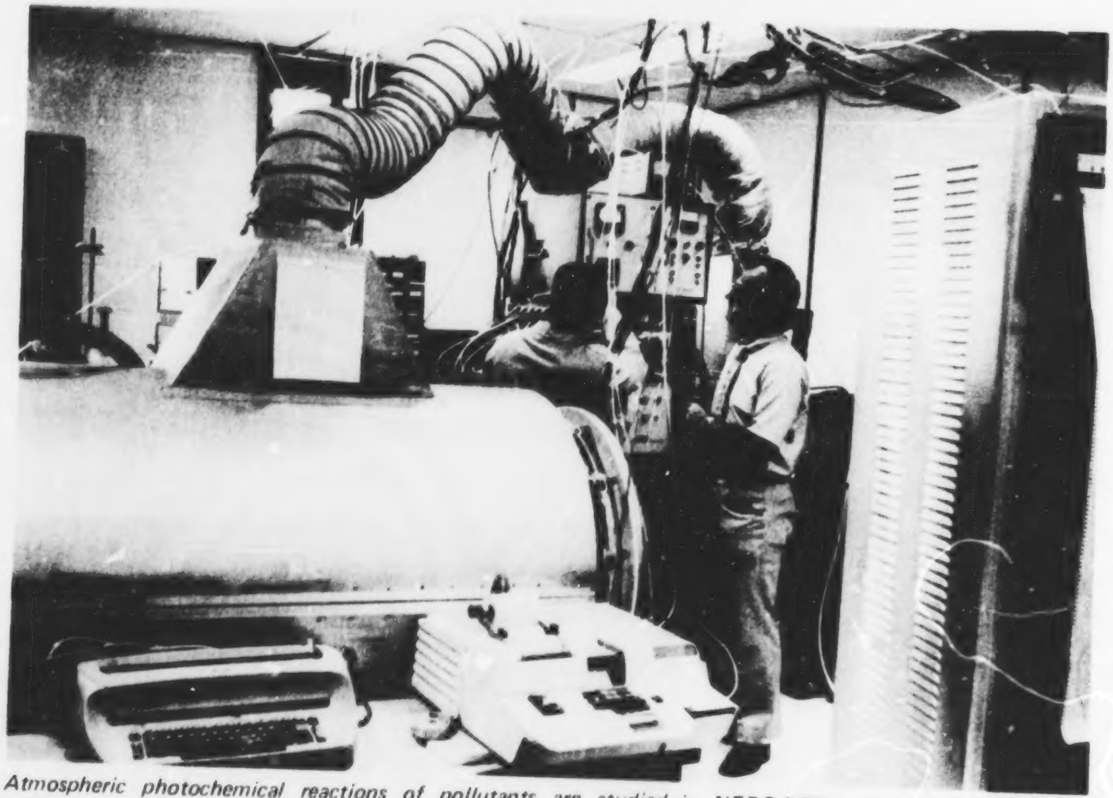


Pollutant emission patterns from exhaust stacks of stationary sources are simulated using NERC-RTP's wind tunnel. Test automobiles are used in developing measurement methods for mobile sources.

Other research prototype systems include two research infrared spectrophotometers for the remote sensing of emissions from stationary sources. These instruments are also capable of long-path measurement of extended source emissions. The Bendix spectrophotometer is presently computer-programmed to monitor ozone in the atmosphere. The Convair spectrophotometer has scanning capability in the 3-to-5 and 7-to-14 micron wavelength range and much higher resolution (1.0 cm^{-1}) than the Bendix (10 cm^{-1}).

An experimental stationary source simulator is installed in a leased facility at the Beaunit Corporation Technical Center in the Research Triangle Park. This facility is used to generate test flue gases with particulate matter, moisture, and other pollutants under defined conditions–conditions that must be known so that sampling and analysis methods can be evaluated under controlled experimental situations before actual field testing is undertaken. This equipment provides a 2 by 3 by 35 foot test section, up to 450° F (233° C) flue gas temperature, and 80 ft/sec (24 m/sec) flow velocities to simulate conditions encountered in typical power plant operations. Both extractive and cross-stack optical instruments are tested at this facility before actual installation or field testing at combustion sources.

The electron optical facilities include scanning electron microscopy (SEM), transmission electron microscopy (TEM), and X-ray diffraction equipment. The SEM, used for morphological studies of stationary and mobile source particulate emissions, is equipped with two X-ray spectrometers that give it a capability for quantitative and qualitative chemical analysis as well. The wavelength X-ray spectrometer allows conversion of the SEM to an electron microprobe for quantitative chemical analysis of particles smaller than 1 micron in diameter. The energy dispersive X-ray spectrometer allows qualitative chemical analysis, for elements beyond sodium, of particles only a few hundred angstroms in diameter. The TEM is used for examination of particles smaller than 0.1 micron in diameter where crystal structure is an important consideration. Electron diffraction techniques afford a means of identifying the compound species of the particles being examined. X-ray diffraction is used for identification of crystalline material or mixtures. Quantitative analysis is possible from observation of



Atmospheric photochemical reactions of pollutants are studied in NERC-RTP's small "smog chamber."

intensities of X-ray maxima as a function of percentage composition of a crystalline phase.

The mobile source emissions laboratory is used for the observation and delineation of the emissions of mobile sources, their characterization and quantification, and the development of the most precise techniques for their analysis. The wide range of analytical capability includes particulate and gaseous components such as sulfates, fuel additive components, and other nonregulated emissions. This general capability is provided by analytical facilities that include;

- Hitachi RMU-6L mass spectrometer coupled to a Perkin-Elmer 990 gas chromatograph. The mass spectrometer accurately measures the atomic mass of molecules presented to it while the gas chromatograph provides fractionation by the principle of absorption. The mass spectrometer can also analyze gaseous and liquid samples to provide unique information on the molecular weights of the chemical species present.
- Gas chromatography capability for separating and analyzing automotive exhaust by its individual components. This capability typically results in over 100 hydrocarbons and many substituted organic components, and is being expanded to higher molecular weight components. The principles involve selective absorption, elution, and detection using flame ionization detectors that respond with extreme sensitivity to individual carbon atoms. Typical sensitivities are about 0.01 ppm. Special techniques allow these limits to be extended approximately an order of magnitude.
- Other general analytical equipment including NMR (Varian T60), infrared spectrophotometer (P-E 180), UV-visible spectrophotometers (Cary Model 14 and Beckman Model B), chemiluminescent equipment, atomic absorption, microbalances, liquid chromatographs, and other modern analytical laboratory instruments.

The mobile source testing facility is installed at Beaunit's Technical Center in Research Triangle Park. Installed equipment includes a water brake certification dynamometer complete with a constant-volume sampler and a particulate sampling tunnel. Also available for installation are two engine dynamometers for light-duty engines and one engine dynamometer for

Elemental analyses of atmospheric aerosols are conducted using X-ray fluorescence techniques.

heavy-duty engines. Dilution-tunnel and constant-volume samplers are available to allow the measurement of gaseous and particulate emissions. This equipment allows vehicles and engines to be operated under conditions that simulate those encountered by the general population.

These facilities allow the operation of vehicles and engines to permit evaluation of control devices (such as catalysts) and the characterization of non-regulated emissions caused by unusual operating conditions or the use of the other fuel components—either fuel additives or unusual fuels.

The analysis of air for pollutants by long-path infrared spectroscopy was used by the early workers in the field of air pollution to detect ozone as a constituent of smog. A new system, capable of detecting fractional parts per billion (by volume) pollutant concentrations, is operated by CPL personnel. This new long-path irradiation chamber has a basic length of approximately 30 feet; mirrors on each and provide an optical path of over 3000 feet. When this effective path length of air is analyzed with a Fourier Transform Infrared Spectrometer and a computer for nearly instantaneous data analysis, pollutants at concentrations of a fraction of a part per billion (by volume) can be identified and measured. The system is now used to detect pollutants that have not been measured or that have been measured only with difficulty, both in the laboratory and field.

Several mobile laboratories are used for field studies of atmospheric chemistry and physics. These laboratories are equipped with gas chromatographs and ozone, sulfur dioxide, and NO_x analyzers. Aerosol sampling and sizing equipment is available, as well as weather monitoring equipment.

Two smog chambers, soon to be operational, will permit simulation of polluted atmospheres for study of aerosol formation and growth and hydrocarbon/nitrogen-oxide/oxidant reactions. Five chambers are in use for simulating polluted atmospheres to study the effect of such atmospheres on critical materials.

MAJOR PROGRAM AREAS

Principal efforts of personnel of the Chemistry and Physics Laboratory are aimed in two directions: studies of the physical and chemical transformation of atmospheric pollutants, and development of techniques and instrumentation for measuring air pollution. The former includes the interaction of air pollutants with materials and the consequent effects.

Pollutant Transformation

Among ongoing studies in the area of pollutant transformation are those on (1) formation and removal of noxious gases in the atmosphere, (2) effects of aerosol composition on visibility, (3) oxidant/precursor relationships for control strategies, (4) the Regional Air Pollution Study, relating to air quality characterization, (5) the character and origin of aerosols, and (6) effects of air pollutants on organic and inorganic materials.

Formation and Removal of Noxious Gases in the Atmosphere—Transformations of sulfur oxides, nitrogen oxides, and organic pollutants are being identified and described quantitatively. Gas- and condensed-phase processes are both under investigation. Reactivities and reaction paths are being established. Intermediate chemical species as well as final oxidation products are being identified and measured. Real atmospheres are studied with mobile equipment at selected locations. Simulated polluted atmospheres are studied under controlled conditions in the laboratory. Results, being fit into chemical mechanisms, are yielding parameters for the mathematical modeling of the atmospheric transformation processes. The results are disseminated in reports on the chemical and physical processes involved in the formation, transport, and removal of toxic and noxious substances in the atmosphere. Technical papers are published which provide insights into the self-cleansing properties of the atmosphere. Rate and mechanism data are provided for the mathematical modeling of the reactions in the polluted air. Relationships between pollutant emissions and adverse effects are described. Advice is given as to control strategies for minimizing the formation of noxious gases in the atmosphere. Nearly all of the nine atmospheric noxious gas tasks under way are multi-year projects which will be continued. Three of these tasks are described below.

Field Studies of Gaseous Pollutants—The objectives of these studies are to characterize the St. Louis and Houston atmospheres. CPL interest includes compositional differences as well as similarities of air samples as a function of time of day and sample site location. Of principal interest is the hydrocarbon distribution, NO_x concentration, and oxidant production in these two cities. Future work of this type will involve vinyl chloride and other halogenated pollutants in Houston, and oxidant transport in the Ohio/Indiana area.

Los Angeles Reactive Pollutant Study—This study, a cooperative program with the Coordinating Research Council, is now in its data analysis and reporting phase; it may be concluded next year. An attempt is being made to develop a model of a reacting and moving parcel of polluted air in the Los Angeles area. Measurements were made on such pollutants as NO, NO_2, O_3, CO, and hydrocarbons. Samplers were both airborne and groundbased. Air movements were tracked with tetroons and radar.

Halogenated Compounds in the Atmosphere—This research grant task at Rutgers University is concerned with the measurement, tropospheric reactions, and lifetime of freons. In the past several years, the use of fluorinated hydrocarbons has increased considerably. Lovelock's tropospheric measurements show that levels of Freon 11 and 12 in the atmosphere are increasing almost proportionately to the emission rates. This work will look into possible removal processes for the freons. If no removal processes can be found, then recommendations will probably have to be made on the wisdom of the buildup of non-reactive halocarbons in the atmosphere. Work during the coming year will be expanded to allow increased field measurements, using a mobile laboratory.

Effects of Aerosol Composition on Visibility—Visibility reduction is the most obvious effect of atmospheric pollution, but ironically it is not well understood. It is recognized that visibility is spoiled by light scattering from aerosol particles, but the physics of the scattering phenomenon and the chemistry of the formation and growth of the scattering particles have not been adequately explained. In order to bring visibility loss under control, further scientific study of its causes is required.

The output of the program will include (1) optical properties of primary and secondary aerosols; (2) relationships between visibility loss and aerosol characteristics such as size, shape, and chemical composition; (3) effects of relative humidity on aerosol properties; (4) scientific data for visibility criteria and standards; and (5) data from which to derive pollution control strategies that will improve atmospheric visibility.

Determination of Oxidant/Precursor Relationships for Control Strategies—Oxidants are legally controlled pollutants, but they are not emitted directly to the atmosphere. An oxidant is formed in the air by photochemical reactions involving NO_x, oxygen, and hydrocarbons. The word oxidant designates material that causes an oxidation reaction in certain test procedures. Oxidant generally consists of about 90 percent ozone and 10 percent peroxyacyl nitrates.

Control of oxidants follows from control of their precursors—NO_x and hydrocarbons. Permissible limits of the precursor concentrations must therefore be based on knowledge of the photochemical processes in the air. The oxidant/precursor relationships must be determined in quantitative detail.

The problem is studied in laboratory simulations that yield precise but indirect determination of the oxidant/precursor relationships. Field studies are also being carried out for approximate but direct determination of the relationships. From the results of all the studies, empirical relationships between the chemical variables are derived.

Regional Air Pollution Study: Air Quality Characterization–The monitoring network of the RAPS will measure gaseous pollutant concentrations and meteorological variables for use in modeling the transport of the pollutants in the urban air mass. The network will have little impact on describing and modeling the transformations of the pollutants, however, especially aerosol formation and growth. It has therefore been necessary to establish this subprogram which addresses atmospheric chemistry problems.

A team of experienced aerosol scientists was assembled in St. Louis in the summer of 1973 to conduct an intensive aerosol characterization program. Previous experience with the California aerosol was the basis for the development of the aerosol study. Special EPA mobile facilities were used for aerosol characterization. The results of the study are currently being analyzed and developed for publication. Two gaseous pollutant transformation projects have been under way: the first is the study of the transformations of NO_x and SO_x in power plant plumes; the second is laboratory verification of the kinetic models that are to be applied to the network data.

The program output includes: identification of sources of visibility loss in St. Louis; specifications of particle sizes, size spectra, and chemical composition; fine-particle spatial distribution; identification of gas/particle interactions for development of visibility reduction models; data on choice of tracer substances for study of regional atmospheres; and chemical inputs to the photochemical modeling effort.

Character and Origin of Aerosols–Physical and chemical properties of source, ambient, and natural aerosols are being determined. Aerosol generation rates for various sources are being established. The major sinks for aerosol pollutants are being identified and the removal rates are being defined. The effects of the aerosols on gas-phase atmospheric chemical reactions are under investigation, along with the gas/particle conversions and the particle-removal processes. The results of the research are being used to establish the contribution of the various sources to the ambient atmospheric aerosol loading; characterize urban, natural, primary source, and secondary source aerosols; develop quantitative descriptions of generation and removal rates associated with each major aerosol source and sink; and quantify aerosol effects on atmospheric chemical reactions. The scientific data are basic to the promulgation of fine-particle criteria and standards and to the development of effective control procedures.

Relating Fine-Particle Aerosols to Sources–The pollution aerosol is a dynamic system whose physical and chemical characteristics depend in a complex way on the background aerosol and on particle and gas emissions. The goal of this research is to develop experimental and theoretical methods for relating the properties of the pollution aerosol to the characteristics of emission sources. This is being accomplished by (1) beginning with the observed characteristics of the pollution aerosol and formulating a set of hypotheses relating the aerosol to the sources of particles and gases; (2) carrying out laboratory experiments and theoretical calculations aimed at testing these mechanisms, and (3) arriving at a tested quantitative understanding of the origins of the smog aerosol. Experimental studies include investigations of the conversion of organic gases and SO_2 to particulate matter in an ozone-rich atmosphere.

On-the-scene research into atmospheric aerosol behavior is performed using NERC-RTP's mobile laboratory.

Air Pollutant Effects on Organic and Inorganic Materials–The interaction of gaseous and particulate pollutants with material surfaces is of vital interest from two points of view: (1) the damage inflicted on man-made materials by acidic vapors, soot, and other airborne matter is of concern, and (2) the uptake of pollutants by the surfaces is a major removal path and must be understood quantitavely for development of atmospheric models and control plans.

Statistically designed, controlled-environment laboratory experiments are being used to establish cause/effect relationships between pollutants and materials. Laboratory experiments with SO_2, NO_2, and O_3 are being carried out on an intramural basis. The results of these studies will include reports and documents on the direct and synergistic effects of air pollutants on nine classes of sensitive, economically important materials. Final reports will contain dose/response data, at pollution levels below primary standards, that may be used to set secondary air quality standards. Quantitative data will be generated on the rates of uptake of individual pollutants by surfaces of various types.

In the materials-damage survey, an evolved, two level, fractional, factorial experiment has been conducted, using controlled-environment chambers, to screen and assess the damaging effects, both direct and synergistic, of SO_2, NO_2, O_3, and climatic parameters on steel, galvanized aluminum, tires, paints, plastics, fabrics and dyes, marble, and concrete.

Based on the results of this experiment, a more definitive orthogonal-square, controlled-environment experiment will be designed and conducted during the coming year to produce dose/response relationships for materials found to be sensitive to air pollution, both directly and synergistically.

Two additional programs will be undertaken in 1974. The first will be a multi-year field study of pollutant effects on materials, to be conducted in St. Louis with the assistance of Rockwell personnel who are contractors for the RAPS. Materials will be exposed at selected locations and examined periodically for damage. An effort will be made to correlate observed damage with measured pollution levels. The second new undertaking will be a laboratory investigation of the uptake of pollutants by various types of materials.

Pollutant Measurement

Work relating to air pollution measurement, the second of CPL's two major functional work areas (the first is pollutant transformation studies), includes (1) new and improved methods for measuring and analyzing ambient air particulates, (2) personal exposure dosimeters, (3) fine particulate methodology, (4) the RAP's gaseous pollutants in ambient air, (5) mobile source emissions, (6) gaseous pollutants emitted from stationary sources, (7) criteria for selection of stationary source measurement strategies or methodology and instrumentation, and (8) particulates and hazardous substances emitted from stationary sources.

Ambient Air Particulate Measurement and Analysis Methods The aim of this project is to provide EPA with the capability for measuring parameters judged to be relevant to pollution of the atmosphere by suspended particles. Parameters of present concern include mass, particle-size distribution, elemental composition, and visibility attenuation.

Considerable progress has been made in the design of collectors capable of segregating particles in two sizes regimes (0 to 3.5 and 3.5 to 20 microns) on a Teflon surface. Exposed filters are examined for mass determination by Beta-ray attenuation, and for elemental composition by X-ray fluorescence. Filters, filter holders, filter transport mechanisms, and identification coding and decoding devices have been or are being designed for total compatibility, resulting in a system geared to the handling of large numbers of samples with minimum opportunity for human error.

A major step forward was the development of a simple, sensitive, and reasonably specific device for the automated collection and quantification of sulfuric acid mist. Early evaluation is planned. A similar device capable of measuring particulate nitrate is also being developed.

The X-ray fluorescence technique for measurement of trace elements in airborne particles has been notably improved through updated computer programming that eliminates inaccuracies previously incurred as a result of variations in particle size.

Future efforts will include further improvements in collection, sizing and analyzing techniques, and development of objective methods of assessing visibility reduction.

Important progress was made toward development of a rapid method for the measurement of benzo(a)pyrene, an important carcinogenic component of pollutant particles.

Personal Exposure Dosimeters This program, new in 1973, is aimed at providing simple devices that will record the exposure of individuals to specific pollutants, independently of movements of those individuals within and between areas of differing pollutant levels.

A major initial contract procurement effort is directed toward preparation of a state-of-the-art survey to identify available measurement techniques, to clarify uncertainties in informational needs (e.g., time resolution, sensitivity, and precision) and to assess the degree to which it may be reasonably assumed that existing miniaturization techniques can be applied to the several candidate measurement methods. Concurrently, procurement is being sought for a small number of prototype sensors for pilot use and evaluation. Such pilot use will aid in establishing realistic design criteria for future prototype procurements.

Fine-Particulate Methodology–The objective of this program is to develop a simple, low-cost, 2- or 3-stage device that will effect the dichotomous collection of respirable and non-respirable particles from ambient air in a manner compatible with subsequent assessment of their mass and chemical composition.

During 1973, laboratory and preliminary design work led to initiation of a procurement for the fabrication of prototype 2-stage collection devices that will be fieldworthy yet amenable to production at moderate ($2,000) cost. Design criteria include an intake section whose performance will not be seriously affected by wind direction or speeds of up to 15 km/hr.

Future activity will include field evaluation of the product of the procurement described above and fabrication of improved second-generation prototypes. Every effort will be made to provide the capability of real-time assessment of fine-particle burden in the final product. A corollary activity is the development of reliable methods for generating monodisperse aerosols of precisely known particle size for use in the calibration of sizing instrumentation.

RAPS Measurements and Instrumentation–The objective of this program is to provide measurement capabilities necessary to complete the Regional Air Pollution Study. The major accomplishment in 1973 was the awarding of a contract for activation and operation of Regional Air Monitoring System (RAMS) to Rockwell International.

An X-ray flourescence analyzer was fabricated, providing RAPS with the capability of analyzing collected particulate samples for up to 30 elements. Sensitivity and analysis time are sufficient to handle large numbers of samples collected over periods of 2 hours or more.

Twelve automated dichotomous samplers were fabricated to collect particulate samples, segregating respirable from non-respirable fractions. A Beta-gauge was developed to assess the mass of particles in each fraction collected. This gauge will be fabricated to handle the same samples collected for X-ray analysis.

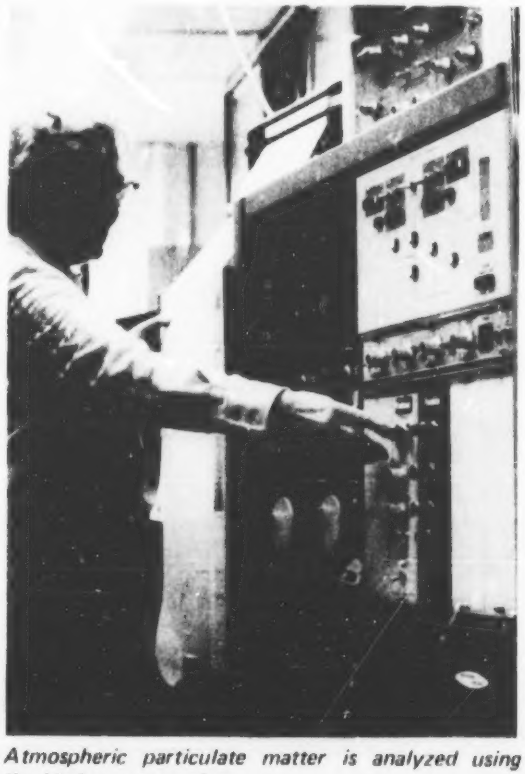
Two separate, laser-powered, long-path spectrophotometers were developed for use in RAPS for determining gaseous pollutant burdens, averaged over line-of-sight paths of up to 1 kilometer. Results will be utilized in improving pollution-transport modeling capability. These instruments are capable of analyzing for CO, O_3, SO_2, and other pollutants.

A contract was let for fabrication of a fluorescence instrument for measuring NO_2. This, a direct measurement, will assist in confirming data generated by chemiluminescence (indirect) instruments in RAMS.

A gas-chromatographic instrument capable of measuring acetylene at levels of 0.1 ppb was fabricated under contract. This capability will be used in studies applying acetylene as an intrinsic tracer substance indicative of automotive traffic.

Further work in this task will consist largely of field trials and applications of the techniques described above.

Instruments for Measuring Gaseous Pollutants in Ambient Air–The objective of this program is to provide EPA with both instrumental and laboratory methods for the measurement of important gaseous pollutants such as ozone, NO_x, SO_x, CO, and hydrocarbons. Its aims are: to provide measurement capability for a specific pollutant where a need is known to exist; to improve that capability to an EPA-acceptable level of reliability; to simplify the hardware resulting from initial efforts to a degree permitting routine operation of the method or instrument by personnel available to enforcement agencies; and to seek design optima (or alternate methods/instruments) that will facilitate proliferation at costs commensurate with EPA resources.



Atmospheric particulate matter is analyzed using liquid chromatography.

Benzo(a)pyrene in atmospheric particulate matter is measured using a CPL-developed instrument.

Mobile Source Emissions

Activities encompassed in this task include the definition, description, and measurement of emissions from all mobile sources. Possible emissions are investigated and techniques for their measurement are developed. The operational parameters of this measurement are defined so that the critical health-related questions can be investigated. Physical and kinetic considerations are addressed in order to define practical limits of consideration. Emphasis is on currently nonregulated emissions that might have the greatest impact on our environment. Techniques for the measurement of regulated emissions are continually reviewed to ensure their efficacy.

In the past year, methodology has been delineated to routinely perform analyses of hydrocarbons, nonreactive hydrocarbons, and diesel odors. Methodology is being developed to assess sulfate emissions and to measure SO_2 in exhaust.

Major efforts have been expended to define particulate emissions and the technology for measuring them. This work has led to the measurement of particulates from a wide variety of light-duty vehicles, including vehicles operated on nonstandard fuels, with and without catalysts, and with and without other novel control systems. Projects are currently under way to extend these techniques to heavy-duty vehicles and other mobile sources.

Gaseous Pollutants Emitted from Stationary Sources

The objectives of this project are to develop and evaluate measurement techniques and monitoring systems for gaseous emissions in support of control regulations for selected industrial sources. The research and development program consists of one or more of the following efforts to meet the required needs:

establish the state-of-the-art, conduct feasibility studies of new or improved concepts and evaluate their application to specific gas pollutants, develop and evaluate field prototypes, and evaluate commercially available prototype systems. Methods and measurement systems include improved manual methods, in-stack instrumentation, and remote sensors for sulfur-containing compounds, NO_x, halides, CO, hydrocarbons, and odorous materials. Also involved is the development of supporting technology including both flow and temperature measurements as well as sample-conditioning mechanisms.

Selection of Criteria for Stationary-Source Measurement Strategies—The objectives of this activity are to develop performance criteria for prescribed methods and monitoring systems and to establish test procedures by which criteria can be verified. These criteria and procedures provide the technical data to support the prescribed methods and monitoring requirements and to assess the capability and accuracy of equivalent or alternate measurement methods.

Compliance test methods for NO_x and SO_2 were evaluated at coal-burning power plants; monitoring systems for these pollutants were tested under field operating conditions. A technical document was completed on performance specifications and test procedures for monitoring systems for NO_x, SO_2, and visible emissions from Group I stationary sources.

Particulates from Stationary Sources

The objective of this project is to develop and evaluate measurement techniques and monitoring systems in support of regulations for selected industrial sources. The research and development program consists of one or more of the following efforts to meet the required needs, establish the state-of-the-art, conduct feasibility studies of new or improved concepts and evaluate their application to specific particle parameters, develop and evaluate field prototypes, and evaluate commercially available prototype systems.

Hazardous Substances Emitted from Stationary Sources

The first group of substances designated for national emission standards for hazardous air pollutants includes asbestos, beryllium, and mercury. Future designations may include such materials as toxic metals (Pb, Cd, V, Ni, Co, Cr, Mn, As, and Se) or groups of polycyclic organic matter (POM). The purpose of this work is to develop measurement methods to obtain reliable emission data and to support emission standards for these substances. The program consists of one or more of the following approaches to achieve a working method or system: feasibility study of new concepts and their evaluation for specific pollutants, development and evaluation of a research prototype, development and evaluation of a field prototype, and evaluation of commercial prototype systems.

Quality
Assurance
and
Environmental
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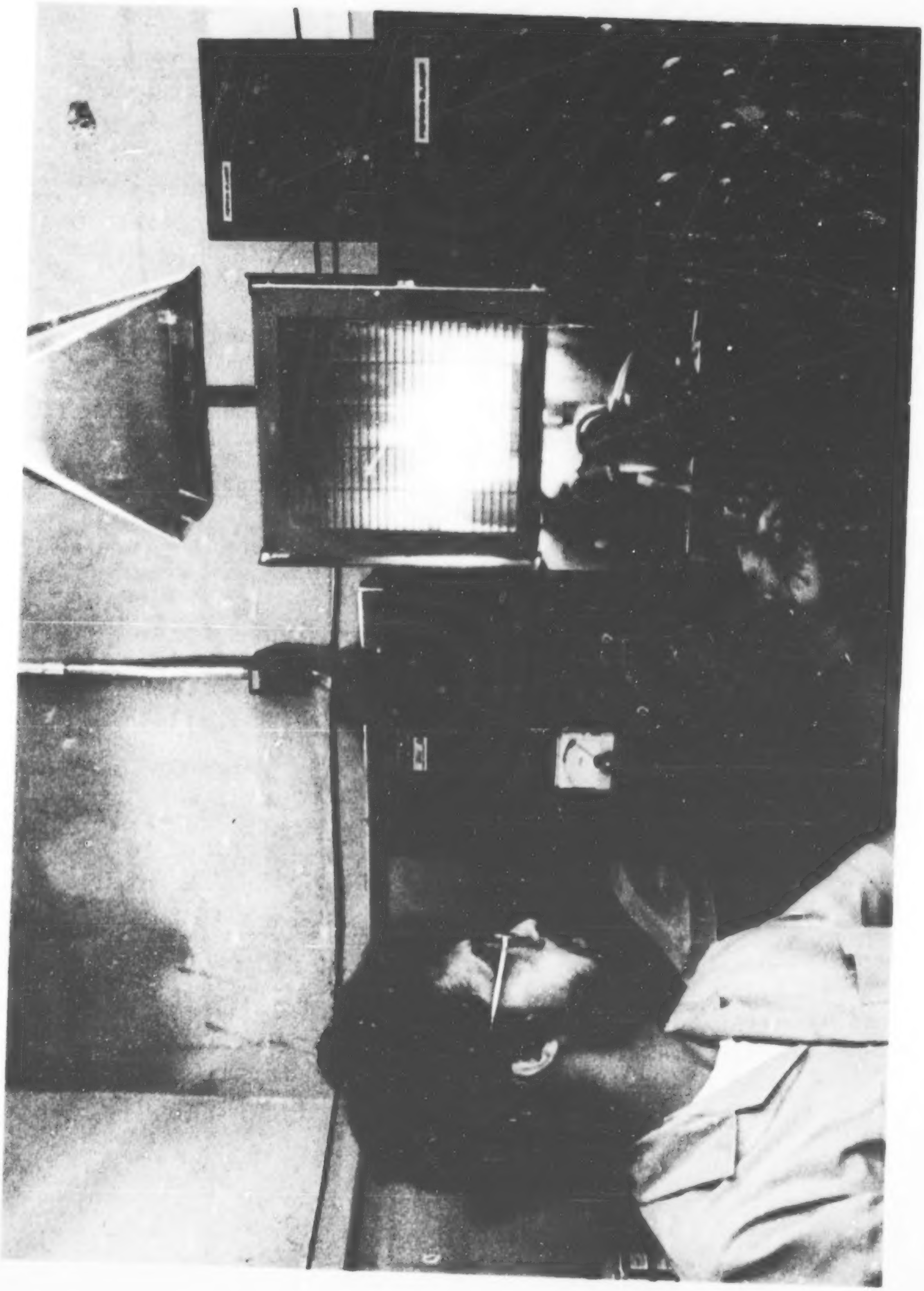
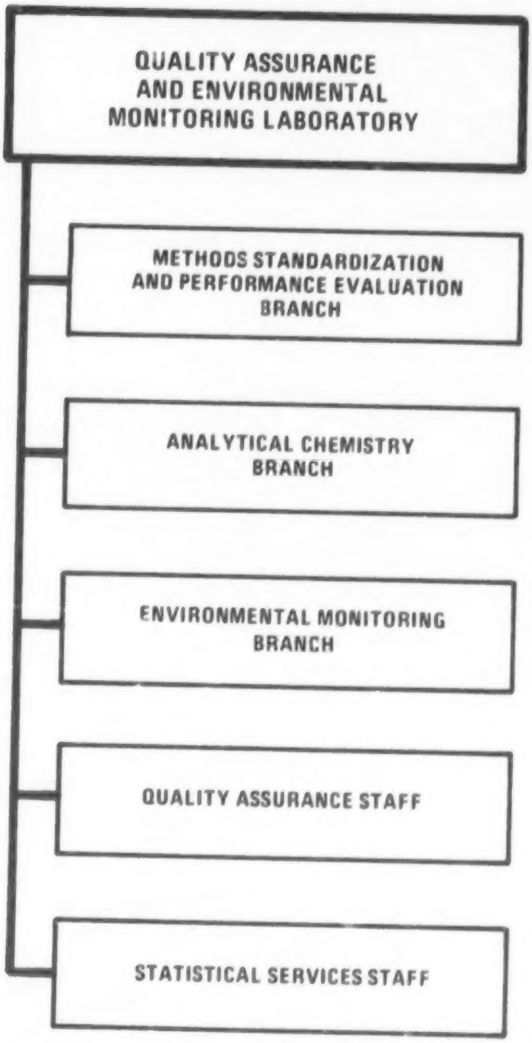
Laboratory



Quality Assurance and Environmental Monitoring Laboratory


QUALITY ASSURANCE AND ENVIRONMENTAL MONITORING LABORATORY
METHODS STANDARDIZATION AND PERFORMANCE EVALUATION BRANCH
ANALYTICAL CHEMISTRY BRANCH
ENVIRONMENTAL MONITORING BRANCH
QUALITY ASSURANCE STAFF
STATISTICAL SERVICES STAFF

Studies to determine the chemical and physical composition of fuel additives are conducted by the Quality Assurance and Environmental Monitoring Laboratory. Research techniques include the analysis of gasoline for lead using an atomic absorption spectrophotometer

OVERVIEW OF QAEML'S MISSION

The mission of the Quality Assurance and Environmental Monitoring Laboratory (QAEML) is to obtain the data needed to reach and support decisions concerning environmental quality, particularly in the air medium. Such data are needed in a variety of activities such as air quality management, criteria development, standards setting, compliance and enforcement, emergency episode control, and source emission control strategy.

In carrying out its mission, QAEML provides monitoring services that range from the first steps of any monitoring effort—selecting field sites for monitoring and making measurements on such sites—to the final steps of data evaluation, summarization, and dissemination. Quality assurance is practiced to control and document the quality of the data obtained. Although the use of standardized methods is an important aspect of quality assurance, such methods are not always available

To supplement the use of standardized methods, QAEML maintains expertise in analytical chemistry, instrument electronics, and statistics to ensure that method development and evaluation, formal testing (including collaborative testing in the community of users), and quality control procedure development can be carried out effectively. Quality control procedures are formalized and disseminated for use within EPA, by the states, and by other interested groups.

Data evaluation and summarization of information routinely obtained in the environment and of information about analytical methods are provided for the community of users by appropriate statistical analyses and summaries. Data are entered into the National Aerometric Data Bank or are published through appropriate channels.

LEGISLATIVE MANDATE

The mission of QAEML responds to eight sections of the Clean Air Act (103, 108, 110, 111, 112, 113, 211, and 313). The various sections are shown below with brief descriptions of the types of supportive activities.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **"Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution and as part of such program shall—"(1) conduct and promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys**

and studies relating to the causes, effects, extent, prevention, and control of air pollution; . . . (3) conduct investigations and research and make surveys concerning any specific problem of air pollution in cooperation with any air pollution control agency with a view to recommending a solution of such problem, if he is requested to do so by such agency or if, in his judgment, such problem may affect any community or communities in a State other than that in which the source of the matter causing or contributing to the pollution is located; . . .

"(b) In carrying out the provisions of the preceding subsection the Administrator is authorized to—

"(1) collect and make available, through publications and other appropriate means, the results of and other information, including appropriate recommendations by him in connection therewith, pertaining to such research and other activities; . . ."

QAEML responds to Section 103 by evaluating, testing, and standardizing methods. Quality control procedures for relevant methods are also developed.

Material samples involved in lawsuits are carefully handled to maintain chain-of-custody requirements and are sealed in locked storage cabinets (inset).

Surveys and investigations are undertaken, both of the general extent of air pollution and of specific problems. The voluminous data that result are appropriately summarized, analyzed, and disseminated.

"AIR QUALITY CRITERIA AND CONTROL TECHNIQUES

"Sec. 108. (a) (2) The Administrator shall issue air quality criteria for an air pollutant within 12 months after he has included such pollutant in a list under paragraph (1). Air quality criteria for an air pollutant shall accurately reflect the latest scientific knowledge useful in indicating the kind and extent of all identifiable effects on public health or welfare which may be expected from the presence of such pollutant in the ambient air, in varying quantities . . .

"(c) The Administrator shall from time to time review, and, as appropriate, modify and reissue any criteria or information on control techniques issued pursuant to this section . . . ."

QAEML responds to this section of the law by standing ready to evaluate methodology used to obtain scientific information or to undertake surveys to obtain information needed by those who must develop criteria documents.

"IMPLEMENTATION PLANS

"Sec. 110. (a) (1) Each State shall, after reasonable notice and public hearings, adopt and submit to the Administrator, within nine months after the promulgation of a national primary ambient air quality standard (or any revision thereof) under section 109 for any air pollutant, a plan which provides for implementation, maintenance, and enforcement of such primary standard in each air quality control region (or portion thereof) within such State. In addition, such State shall adopt and submit to the Administrator . . . a plan which provides for the implementation, maintenance, and enforcement of such secondary standard . . .

"(2) . . . The Administrator shall approve such plan . . . if he determines that it was adopted after reasonable notice and hearing and that— . . . (C) it includes provision for . . . appropriate devices, methods, systems, and procedures necessary to (i) monitor, compile, and analyze data on ambient air quality . . . ."

This section of the law is supported by QAEML's activities in the evaluation and standardization of methods for the criteria pollutants and in the development and dissemination of quality control procedures for standardized methods. Use of the standardized methods with quality assurance documentation provides the ability to meaningfully compare data collected routinely by many unrelated State agencies.

"STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

"Sec. 111. (b) (a) (B) . . . the Administrator shall propose regulations, establishing Federal standards of performance for new sources . . .

> **"(c) (1) . . . If the Administrator finds the State procedure is adequate, he shall delegate to such State any authority he has under this Act to implement and enforce such standards . . . ."**

This requirement is analogous to that of Section 110 of the Act; QAEML supports this section similarly.

> **"NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS**
>
> **"Sec. 112. (b) (1) (B) . . . the Administrator shall prescribe an emission standard for such (hazardous) pollutant . . .**
>
> **(d) (1) . . . If the Administrator finds the State procedure is adequate, he shall delegate to such State any authority he has under this Act to implement and enforce such standards . . . ."**

This requirement is similar to those of Sections 110 and 111 of the Act. QAEML's support is also in terms of methods standardization, evaluation, and quality control procedure development. Some technical assistance is also rendered to obtain data to assist the Administrator in making judgments as to what constitutes a hazardous pollutant.

> **"FEDERAL ENFORCEMENT**
>
> **"Sec. 113. (a) (1) Whenever, on the basis of any information available to him, the Administrator finds that any person is in violation of any requirement of an applicable implementation plan . . . the Administrator may issue an order requiring such person to comply with the requirements of such plan or he may bring a civil action . . ."**

QAEML maintains a limited rapid-response capability to assist in the collection of data for purposes of Federal enforcement.

> **"REGULATION OF FUELS**
>
> **"Sec. 211. (a) The Administrator may by regulation designate any fuel or fuel additive and, . . . no manufacturer or processor of any such fuel or additive may sell, offer for sale, or introduce into commerce such fuel or additive . . ."**

QAEML's support of the law consists of the development and evaluation of methods of analyses and of the collection and analysis of fuel samples as required.

> **"ADDITIONAL REPORTS TO CONGRESS**
>
> **"Sec. 313 . . . the Administrator shall report to the Congress on measures taken toward implementing the purpose and intent of this Act . . ."**

When the inclusion of data or method developments developed by QAEML is relevant, the information is provided to support this provision of the Act.

Table 12. SUMMARY OF RESOURCES FOR QUALITY ASSURANCE AND ENVIRONMENTAL MONITORING LABORATORY FOR FISCAL YEAR 1974

Section of Clean Air Act supported	Funds, $\$10^3$	Positions	Approximate percent
103	833	28	26
108	90	3	3
110	1182	14	37
111	405	10	13
112	274	8	8
113	103	3	3
211	225	1	7
313	112	6	3
Total	3224	73	100

ORGANIZATION

The Quality Assurance and Environmental Monitoring Laboratory conducts its activities through four technically oriented branches and a statistical group, all of which report directly to the Office of the Director. All activities are coordinated through the Office of the Director, which also serves as the interface with other EPA units for which QAEML provides technical support. Table 12 shows the percentages of funds and personnel used by QAEML in Fiscal Year 1974 to support various sections of the Clean Air Act.

Quality Control Branch

The Quality Control Branch (QCB) provides guidance on development and implementation of quality assurance programs to NERC-RTP laboratories, EPA Regional Offices, and State and local laboratories to ensure that all aerometric data used in the various decision-making processes are valid and comparable. The Branch develops standard reference samples and delivery systems for use in quality control and certification programs.

Methods Standardization Branch

The Methods Standardization Branch (MSB) develops and conducts a methods standardization program involving laboratory evaluation, procedure revision, and collaborative testing. The end products are standard analytical methods for the measurement of pollutant concentrations in ambient air and those emitted from sources. The Branch develops standard reference materials for methods standardization and calibration.

Environmental Monitoring Branch

The Environmental Monitoring Branch (EMB) is responsible for the installation, calibration, operation, and maintenance of special multipurpose pollutant monitoring stations and networks such as the turbidity, precipitation, and membrane-filter particulate networks, and for providing guidance to other governmental agencies in the design and operation of monitoring stations and networks. The Branch provides specialized field monitoring support (including activities during emergency episodes) to the Office of Air Quality Planning and Standards, the Office of Enforcement and General Counsel (OEGC), and the Regional Offices. It is also responsible for the determination of equivalency of candidate methods and instruments for published reference methods, and for the in-house and field evaluation of commercially available environmental monitoring instrumentation.

Analysis of phosphorus in gasoline is included in fuel tests conducted at NERC-RTP.

Analytical Chemistry Branch

The Analytical Chemistry Branch (ACB) provides analytical capability to NERC-RTP for the measurement of trace elements and other pollutants present in various environmental, bioenvironmental, source, and fuel samples. The Branch provides technical support and specialized training to EPA Regional, State, and local laboratory personnel. As required, the ACB develops new methods, modifies existing methods, and provides analytical services in support of ongoing studies including research monitoring. The Branch is also responsible for maintaining liaison with and giving technical assistance to the Office of Air Quality Planning and Standards with respect to source sampling and analysis methodology for trace elements and other pollutants to provide valid data for development of source performance standards. ACB personnel provide analytical laboratory services to OAQPS, OEGC, or other EPA programs for short-term and special environmental studies in support of trend monitoring in such areas as State Implementation Plans and enforcement actions.

Statistical Services Staff

The Statistical Services Staff (SSS) provides statistical competence to QAEML by participating in the statistical design, execution, and analysis of quality assurance, methods standardization, and monitoring studies. Personnel carry out mathematical and statistical evaluation and report on internally generated data. The Staff is a focal point within NERC-RTP for handling, processing, and reporting aerometric data received from the World Health Organization and the World Meteorological Organization.

PHYSICAL FACILITIES

QAEML personnel are housed at NERC-RTP, in Monsanto's Research Building (located at RTP), and in the Durham Air Monitoring and Demonstration Facility (DAMDF). The Laboratory either owns or has access to a number of special instruments and facilities to support its mission.

The Durham Air Monitoring and Demonstration Facility is a specially designed and equipped multipurpose facility utilized for the following functions:

- To demonstrate advanced air monitoring techniques.
- To test and field-evaluate commercially available ambient air monitors, calibration techniques, and data acquisition systems.

- To gather pollutant concentration data generated from special intermethod comparability studies.
- To provide capability for methods and instrument equivalency testing.
- To provide on-the-job-training.

For special field studies, vans are available to carry calibration and maintenance equipment or to be converted on short notice into air monitoring stations. For projects requiring more elaborate air monitoring equipment, mobile laboratories are utilized which, when fully equipped, are able to monitor for the criteria pollutants and common meteorological parameters.

Laboratory facilities used for the analysis of ambient, source, fuel, and fuel additive samples by optimized procedures include specialized space that allows analysis of fuels and fuel additives under safe conditions.

The analysis of samples by neutron-activation techniques is made possible by use of facilities leased from North Carolina State University. The University's pulstar reactor is used (under control agreement) to irradiate the samples, which are later counted with QAEML-owned equipment located in the rented space.

The 25-channel, direct-reading optical emission spectrometer has been optimized for the determination of trace elements in particulate matter. A spark-source mass spectrometer that can be used to measure small concentrations of trace elements of possible health significance is being activated to permit analysis of environmental samples of interest and to complement the neutron-activation capability.

Development of an Automated Laboratory Data Analysis System, nearing completion, will allow rapid output of validated laboratory analyses—a capability not now possible.

MAJOR PROGRAM AREAS

Methods Standardization

Methods standardization, which directly supports Sections 103, 110, 111, and 112 of the Clean Air Act, is an important component of the quality assurance system necessary to generate valid data. The standardization process is being applied to all reference methods given in regulations for primary and secondary national ambient air quality standards. QAEML is also attempting to standardize some of the methods specified in regulations for new stationary sources and for two of the hazardous pollutants designated thus far—beryllium and mercury. Evaluations by the standardization process are being

Fuel additive samples are carefully catalogued prior to analysis and registration.

carried out for some methods not specified in regulations, and the laboratory is also investigating new techniques for the evaluation of air pollution measurement methods.

Measurement methods are standardized in a two-step process. First, the candidate method is examined in depth in a single laboratory for the purpose of identifying and correcting errors, omissions, ambiguities, and other inadequacies. Second, the candidate method is examined in several laboratories by an interlaboratory collaborative test in which each participant uses the method to measure pollutants contained in a reference material. In this way, the precision and accuracy of the method are measured, and the capabilities of the method in the hands of typical users are estimated.

The levels of ambient air quality for each of the criteria pollutants must be measured by the appropriate reference method (those that were previously discussed with regard to standardization or by an equivalent method). In 1972, a project was initiated to establish definitive requirements and test procedures to determine whether methods of sampling and analyzing the ambient air may be designated "equivalent methods." During this project, continued through 1973, performance specifications and test procedures were developed for three pollutants, carbon monoxide, ozone, and sulfur dioxide. The procedures were tested thoroughly both in-house and by an independent contractor for workability and technical adequacy.

In 1973, numerous achievements were accomplished in methods standardization. The following specific reference materials, required before any collaborative testing of a method (part of the standardization process) can begin, were developed:

- A significant portion of the work to develop a reference material for ambient NO_2 measurements was completed.
- Ozone reference materials were supplied to participants in the collaborative test of the reference method to measure ambient ozone.
- Beryllium reference materials were supplied to participants in the collaborative test of the regulatory method to measure beryllium emissions.
- The Federal reference method for ambient NO_2 was withdrawn during 1973. QAEML assisted in the search for an evaluation of a new method. In partial response to these needs, single-laboratory evaluations of the sodium arsenite procedure, the TGS-ANSA procedure, and a significant portion of the triethanolamine procedure for ambient NO_2 were completed, and a substantial portion of the work required to collaboratively test the sodium arsenite and TGS-ANSA procedures for ambient NO_2 was accomplished.
- The collaborative test of the chemiluminescence reference method for ozone was completed.
- The collaborative test of the 24-hour version of the reference method for measuring ambient SO_2 was finished.
- The collaborative test, in a power plant and in a nitric acid plant, of the regulatory method for measuring NO_x emissions was finished. This method was found to be reliable.
- The collaborative testing of the regulatory method for measuring SO_2 emissions was completed in a power plant and found reliable. A significant portion of the collaborative testing, in a sulfuric acid plant, was also finished.
- A significant portion of the collaborative testing, in a power plant, municipal incinerator, and cement plant, of the regulatory method to measure particulate emissions was completed.
- A significant portion of the evaluation and collaborative testing of the method that measures CO, CO_2, and O_2 in source emissions was completed.
- A portion of the collaborative test of the method to determine visual opacity was finished.
- The field portion of the collaborative test, in a ceramic plant, of the regulatory method to measure beryllium emissions was finished.
- A new technique based on the ganged-probe concept was applied to the evaluation of the method for measuring particulate emissions from stationary sources. This was found to be a useful technique with potential for wide application.
- A program was initiated to evaluate the proposed method to measure H_2S emissions from refineries.
- Test procedures for the determination of equivalent ambient air monitoring methods were developed and tested. The procedures were published as Proposed "Ambient Air Monitoring Equivalent and Reference Methods," *Federal Register*, Vol. *38*, No. 197, October 12, 1973. Comments were considered, and appropriate changes were made to the proposed regulations. The regulations are currently being considered for final promulgation.

Plans for future methods standardization follow the same general direction as in the past, but involve new methods.

Programs for single-laboratory evaluations of at least two ambient sulfate methods, and for collaborative testing of at least one of these, are being developed. The collaborative testing should be completed in late 1975. In 1975 the standardization process for methods to measure benzo(a)pyrene will begin.

Completion of the standardization of the reference method for measuring photochemical oxidants (corrected for interferences due to SO_2 and NO_2) and the beryllium and mercury methods is planned.

The single-laboratory evaluation of the reference method for measuring hydrocarbons should be completed and a decision reached with respect to the methods suitable for standardization.

Completion of the collaborative testing of the method for measuring SO_2 and acid mist emissions from sulfuric acid plants is planned as is further evaluation of the method for measuring particulate emissions. This is a very difficult area and will require examination of the method at a variety of sources subject to regulations.

Evaluation and collaborative testing of the regulatory methods for measuring CO, SO_2, and acid mists from smelters; particulate matter from asphalt concrete plants; particulate matter and lead from lead smelters; fluoride emissions from aluminum reduction plants and phosphate fertilizer plants; total reduced sulfur from Kraft pulp mills; and hydrocarbons from fuel conversion units are planned.

New methods for measuring NO_x and SO_2 emissions from stationary sources will be evaluated if possible.

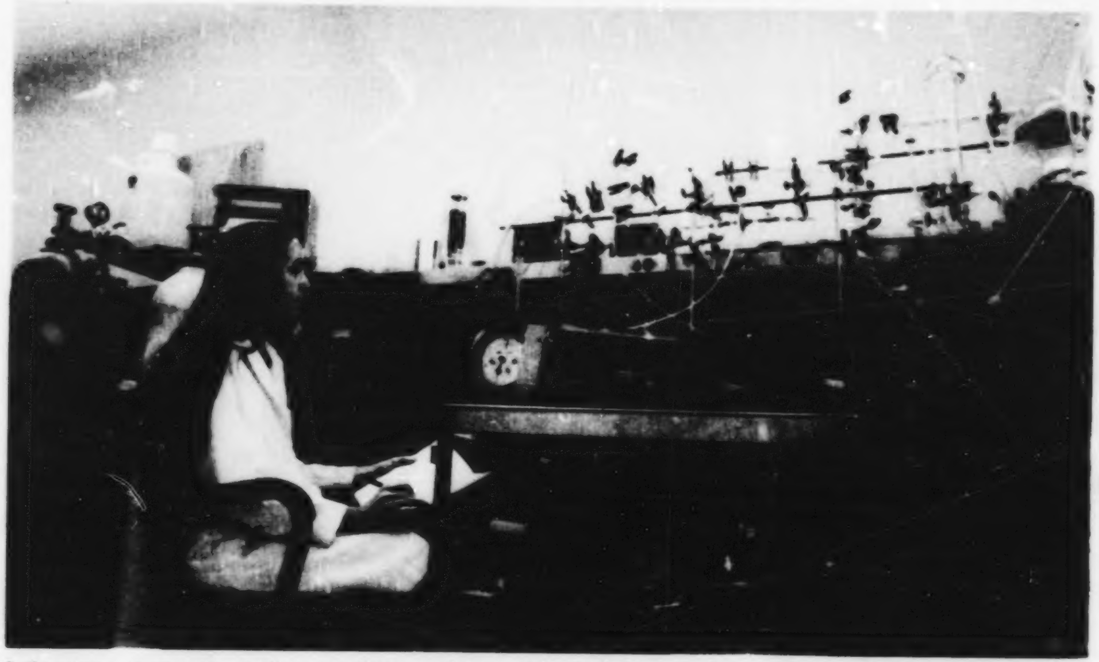
Future work in the area of equivalency determinations will involve the implementation of the regulation requirements, such as reviewing applications for equivalency determinations, testing new and existing air monitors to determine if they meet the requirements of the regulations, publishing a list of acceptable "equivalent" methods, and developing regulations for NO_2 and nonmethane hydrocarbon instruments.

Quality Assurance

QAEML's quality assurance program, in direct support of Section 110 of the Clean Air Act, involves the development of guidelines describing techniques that can be used to:

- Provide routine indication, for operating purposes, of satisfactory or unsatisfactory performance of personnel or equipment.
- Provide for prompt detection and correction of conditions that contribute to the collection of poor-quality data.
- Collect and supply information useful to successfully describe the quality of the data.

Four guidelines, each specific to one method, were developed and published for the reference methods



Laboratory tests are used to evaluate various methods for measuring ambient pollutant concentrations.

for ambient air. Similar documents are being developed for stationary sources reference methods, hazardous pollutant methods, fuel and fuel additive reference methods, and mobile source emission techniques.

Functioning of any quality assurance program requires the routine use of reliable materials of known composition, called "reference materials." Such materials are obtained, and procedures are developed for their use in the calibration of equipment, in quality control checks of components of the measurement process, and in activities that document the data quality. Interlaboratory performance surveys are conducted periodically using these materials. These surveys evaluate overall performance of those organizations participating.

Among QAEML's major accomplishments during the reporting period was the initiation of work on guidelines for the development of quality assurance programs, for use with the new stationary source performance reference methods, and for the reference methods for the hazardous pollutants, mercury and beryllium.

Reference samples were developed for use in quality control programs for measuring SO_2, CO, and particulates in ambient air. Several interlaboratory performance surveys were conducted with the participation each time of about 100 Federal, state, and local laboratories. Surveys were for measuring SO_2, CO, and particulates in ambient air.

Guidelines for quality assurance program development for the method for measuring ozone, CO, SO_2, and TSP in the ambient air were published and distributed.

Future QAEML research will be aimed at developing quality assurance guidelines for newly designated reference methods and revising previously published documents. Test materials for use in interlaboratory quality control performance testing activities conducted by EPA will continue to be developed and refined; interlaboratory performance surveys will be continued, perhaps at an expanded rate.

National Air Surveillance Network

The National Air Surveillance Network (NASN), operation of which supports Clean Air Act Section 103, is a network of about 250 sampling sites distributed all over the nation. Routinely, once every 12 days during 1973, the air at each site was sampled for particulates, SO_2, and NO_2. The amount of particulate matter collected on glass-fiber filters was measured, and the filters were stored in a sample bank. Liquid samples taken to measure NO_2 and SO_2 were analyzed promptly.

A direct-reading emission spectrometer, used to determine simultaneously some 25 trace-element levels in environmental particulate samples, has been modified, greatly improving its precision and lowering detectability limits for most elements.

Several programs for automated data acquisition and analysis, with built-in quality assurance checks, have been constructed, including numerous regression analyses for determining precision.

Among the year's major accomplishments was the analysis of particulate matter samples collected in 1970 and 1971 for some 25 metals, using the improved optical emission spectrometer; the use of a computer reduced the time necessary to process the 162,250 data points produced. Some 300 particulate matter samples from selected sites were taken from the particulate matter sample bank and analyzed for benzo(a)pyrene.

Personnel, resources, and responsibilities for routine NASN monitoring for TSP, SO_2, and NO_2 were transferred to the regions with minimal adverse effects. This transfer was accomplished through training of regional personnel both at NERC-RTP and in the field, and by furnishing complete written instructions in all phases of the NASN activities. Sites were visited, and equipment was replaced and/or updated as needed. Quality assurance assistance was rendered to all of the EPA regional laboratories during this transfer of responsibilities. Performance audits for analytical portions of the SO_2 and NO_2 analyses were conducted. QAEML provided in quantity the samples whose concentrations were unknown to the recipients on a schedule such that the quality of the performance of the routine analyses can be estimated. This activity was begun in 1973 and continued. Assistance in quality control of the NASN techniques was also begun in 1973 and will continue.

Although routine operation of the NASN for analysis of the weight of TSP, SO_2, and NO_2 has been transferred from QAEML to the regions, portions of exposed glass-fiber filters collected under regional auspices are still being received and placed in the sample bank. Portions of archived filters will be analyzed for sulfates, nitrates, trace metals, and organic and inorganic constituents to meet the requirements of QAEML's mandate.

Continuous Air Monitoring Program

The Continuous Air Monitoring Program (CAMP), in support of Clean Air Act Section 103, provides a current and ongoing source of information relevant to a wide range of problems associated with air monitoring and surveillance, including operation, maintenance, calibration, and evaluation of air monitoring equipment. This program provides demonstration and on-site training in the use of sophisticated state-of-the-art instrumentation and procedures throughout the United States.

Continuous air monitoring instruments were evaluated and optimized during the year, and calibration techniques were developed to support regional needs. CAMP stations in Philadelphia, Denver, and Chicago were transferred to appropriate regional offices. Immediately before the transfer, the equipment was serviced, the instruments were calibrated, and the operators were trained. The exterior of the St. Louis station was replaced and incorporated into the Regional Air Monitoring System (RAMS). The Cincinnati station was disassembled and removed because the site lease could not be renewed.

The Durham Air Monitoring and Demonstration Facility (DAMDF) was utilized to conduct an NO_2 methods comparison study and to evaluate the proposed equivalency regulations. Four methods, currently being considered as candidates for a new reference method for measuring NO_2, were extensively evaluated during November and December of 1973 to determine the comparability of data collected by each method. The study was conducted at the DAMDF utilizing a special ambient air manifold system from which duplicates of each of the four methods could simultaneously sample ambient air spiked with various levels of NO_2. Data were collected continuously for 36 days under various conditions of NO_2 and other ambient pollutant levels. Results of this study are currently being evaluated and will be used to assist in the selection of a new reference method for NO_2.

The DAMDF is now being remodeled to include an improved system for environmental control and general building maintenance.

The latest available continuous monitoring instruments are to be installed at DAMDF. This special multipurpose facility will then be utilized to demonstrate advanced air monitoring techniques, to test and field-evaluate commercially available ambient air monitors and associated calibration and data acquisition techniques to gather pollutant data, to conduct intermethod comparability studies, to provide on-the-job training, and to conduct equivalency testing. Operation of the Washington, D.C., station will continue, and updating of the station will be initiated (within resource availability).

Fuels Surveillance Network

Fuels and fuel additives are collected nationally and analyzed for physical characteristics and chemical composition in support of Clean Air Act Sections 211 and 313.

During the past year, fuels and fuel additives were collected and analyzed routinely. Analyses of the 1500 samples collected in 1972 were completed in 1973. Some certified fuel standards were developed. A round-robin test of the trace-element content of fuels was conducted by some four dozen laboratories using various methods. A paper, "EPA's Fuels Surveillance Network: Trace Elements in Gasoline," was published. The collection and analysis of fuels and fuel additives is an ongoing effort. Results will be made available promptly to appropriate decision-making organizations.

QAEML contributed to the development of a simple, but accurate field test for detecting lead, an atomic absorption spectrophotometric method for detecting lead in gasoline (ASTM-D3237), and a method for detecting phosphorus in gasoline (ASTM-D3231).

Fuel and fuel additive samples were analyzed for possible enforcement actions. Chain-of-custody was maintained so that samples could meet legal evidentiary tests. Samples for possible enforcement were analyzed as received (in most cases, a rapid response was necessary.) Programs for automated data acquisition and analysis have been constructed, including numerous regression analyses for determining precision for internal quality control.

Areas of future study include improvement of techniques for trace-element definition by spark-source mass spectrometry, neutron-activation analysis, and X-ray fluorescence. A computer program to support neutron-activation analysis is being developed, and work is continuing on methodology for analysis for sulfur, lead, and phosphorus in fuels in support of the fuel regulations for OEGC.

Membrane Filter and Precipitation Networks

In support of Clean Air Act Section 103, operation of the 55-station membrane filter network for particulates was maintained; samples were collected and analyzed for atmospheric pollutants of interest. QAEML supported a 20-station Precipitation Network operated jointly by EPA, the National Oceanic and Atmospheric Administration, and the World Meteorological Organization (EPA-NOAA-WMO); samples were analyzed for trace contaminants. Several programs were developed for automated data acquisition and analysis, some of which include built-in quality control checks.

During the year, archived samples collected by the 55-station membrane filter network were analyzed for asbestos. Some 7,000 analyses were performed on precipitation network samples, and the data were provided to interested parties. Membrane filter and precipitation monitoring will be maintained roughly at present levels.

Technical Assistance and Rapid Response Sampling and Analysis

Much of QAEML's activity is prompted by needs for technical assistance in other portions of EPA. For purposes of this report, QAEML's responses to these "outside" needs are described as a group.

During the past year, QAEML developed and optimized methodology for assessment of levels of mercury that may have an adverse effect on human health. The Laboratory also developed and published a method for the sampling and analysis of ambient elemental mercury.

At the request of EPA's Office of Air Quality Planning and Standards, several special studies were conducted to determine the levels of criteria pollutants. For example, EPA disapproved State Implementation Plan smelter regulations; therefore, a special network was implemented to determine the levels of SO_2 in the vicinity of 12 smelters to provide information unon which to base a control strategy to meet the national secondary ambient air quality standards. Specifications were developed for the monitoring equipment, sites were selected, stations were installed, standard operating and quality control procedures were developed, operators were trained, and instruments were calibrated. The network consisted of 23 sites with continuous analyzers, 40 sites with integrating samplers, and 12 meteorological stations. Integrated samples were taken daily, and some 30,000 samples were analyzed for SO_2 under contract. The validated data were submitted to OAQPS and to appropriate Regional Offices.

The levels of NO_2 are being determined at 20 selected stations in Air Quality Control Regions (AQCRs) that may need to be reclassified. The latest state-of-the-art continuous monitoring instruments for NO_2 were used at 42 sites in selected AQCRs. Mandated reclassifications were promulgated based on the decision-making data gathered by this operation. The present network now consists of the 20 stations chosen for continuing evaluation in areas of elevated ambient NO_2 levels. All equipment is calibrated at 4- to 6-week intervals. The validated data are utilized to reclassify the appropriate AQCR with respect to the primary ambient NO_2 standard.

QAEML responded to a request by OEGC for assistance in gathering air quality data for asbestos in the city of Duluth and in the vicinity of the Erie Mining Company and the Reserve Mining Company for possible enforcement action. From June 17 to 30, 1973, a total of 11 sites were monitored in the above areas. QAEML calibrated samplers, trained personnel doing the sampling, and provided technical assistance in chain-of-custody procedures.

OEGC later requested a second extensive asbestos air monitoring study. The August 7-16, 1973, study consisted of monitoring asbestos levels in Metropolitan Duluth, the iron ore loading dock in Duluth, and the vicinity of Erie Mining Company's site at Hoyte Lake. This time QAEML provided equipment operation and data reduction. Chain-of-custody procedures were used for all asbestos samplers at the nine sites.

QAEML's technical assistance rendered in initiating the Southwest Energy Study consisted of developing equipment specifications, procuring hardware, selecting sites, and preparing operating instructions. Installation and calibration assistance was also provided on-site by field personnel.

At the request of OAQPS, a complex source study to obtain ambient CO concentrations was conducted at various shopping centers. Indoor and outdoor levels of CO were determined and compared.

Environmental samples, including those of biological origin, were analyzed for trace-metal constituents. Instrumental techniques (including atomic-absorption spectroscopy, spark-source mass spectroscopy, neutron-activation analysis, and optical-emission spectrometry) are used for trace constituent analyses in animal and plant tissues, soil and water samples, particulates, and fuels. Services being performed include analysis of biological tissues exposed to metal aerosols, preparation of metal aerosol samples by particle size fractions, development of the Anodic Stripping Voltameter for analysis of trace metals, and development of atomic-absorption spectrometric techniques for analysis of serum and tissue samples.

An impaction collector, for collecting particulate matter according to particle size, was evaluated in the field; results were submitted to the Emissions Measurement Branch of OAQPS.

QAEML personnel assisted OAQPS in making onsite analyses and in obtaining source samples that were analyzed to determine data necessary for the setting of standards of performance for new stationary sources. Sources involved in this effort have been kraft mills and refineries.

Source samples obtained from chloro-alkali plants and from phosphate fertilizer plants were analyzed for mercury and fluorides, respectively.

Future work will include determination of atmospheric levels of TSP, sulfate, nitrate, platinum, palladium, and ruthenium in special samples taken in Southern California before and after introduction of catalytic converters on automobiles.

Methods will be developed for the determination of trace elements of interest in biological matrices such as serum and tissue. Technical assistance will be provided in analyzing both special samples and NASN samples for metal and non-metal inorganics. Special networks will be developed and maintained to gather data to show the influence of the automobile catalysts on the nature and extent of sulfur species in the air and to define background levels of ozone and the patterns of transport of ozone through the air.

An experimental network for the determination of elemental mercury in ambient air will be implemented in the coming year.

Research and development will be conducted to determine the precision of sampling and analysis of precipitation and the effects of storage of samples on the analytical data obtained.

Meteorology
Laboratory

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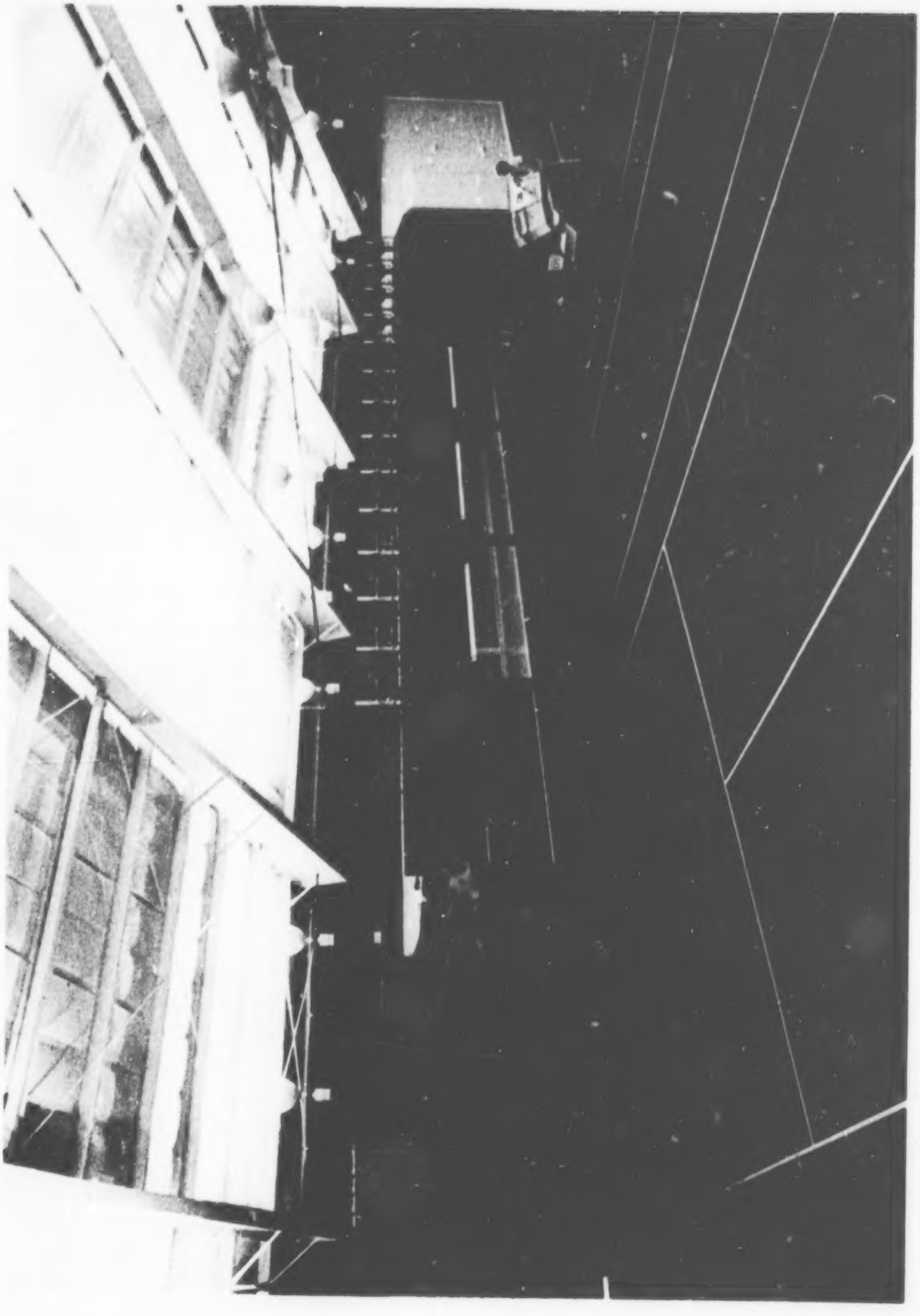
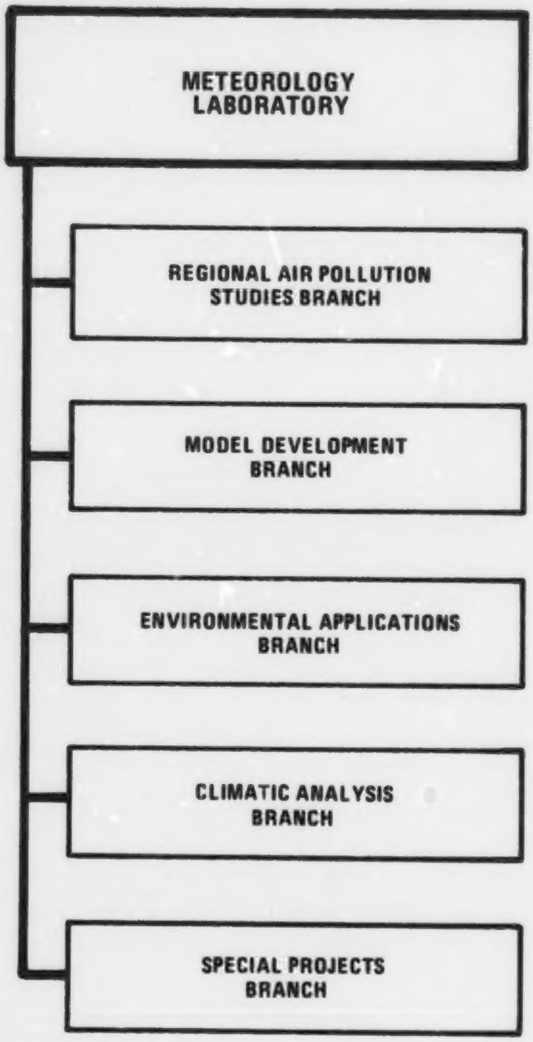


Meteorology Laboratory



Studies of the flow and diffusion of pollutants around building, highway configurations, and complex terrain are conducted in a wind tunnel by the Meteorology Laboratory.

OVERVIEW OF ML'S MISSION

The Meteorology Laboratory (ML) provides an accurate description of the role and interrelationships of atmospheric processes in effective air, water, and land resource management. It provides direct consultation and technical meteorological services; and, through grants, contracts, and personal contacts, promotes meteorological research in concert with EPA's efforts to improve and protect public health and welfare.

ML's contribution to efforts to control air pollution lies in the delineation of the effects of weather and climate on air pollution as well as the effects of air pollution on weather, visibility, and climate. Theoretical and experimental research into the physical processes that affect the transport, diffusion, transformation, and disposition of air pollutants in and from the atmosphere leads to improved techniques for determining and forecasting meteorological aspects of air pollution on a local, regional, or national basis. To this end, the Laboratory develops, evaluates, and disseminates analytical diffusion models, which are used to predict the temporal and spatial distribution of air pollutants. ML also develops sensing techniques for measuring meteorological parameters in urban and rural areas and provides meteorological support to EPA offices and activities in their abatement and compliance efforts.

LEGISLATIVE MANDATE

The major Laboratory effort is directly related to the requirements of Section 103 of the Clean Air Act; however, efforts are also in support of Sections 110, 303, and 313. Pertinent portions of these Sections are quoted below, followed by brief discriptions of the types of supportive actions taken by ML.

> **"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES**
>
> **Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution and as part of such program shall—(1) conduct, and promote the coordination and acceleration of, research, investigations, experiments, training, demonstrations, surveys, and studies relating to the causes, effects, extent, prevention, and control of air pollution; . . ." (3) conduct investigations and research and make surveys concerning any specific problem of air pollution in cooperation with any air pollution control agency with a view to recommending a solution of such problem, if he is requested to do so by such agency or if, in his judgment, such problem may affect any community or communities in a State other than that in which the source of the matter causing or contributing to the pollution is located; . . . . "(b) In carrying out the provisions of the preceding subsection the Administrator is authorized to—**

> **"(1) collect and make available, through publications and other appropriate means, the results of and other information, including appropriate recommendations by him in connection therewith, pertaining to such research and other activities.**
>
> **"(2) cooperate with other Federal departments and agencies, with air pollution control agencies, institutions, and organizations, and with any industries involved, in the preparation and conduct of such research and other activities.**
>
> **"(3) make grants to air pollution control agencies, to other public or nonprofit private agencies, institutions, and organizations, and to individuals, for purposes stated in subsection (a) (1) of this section.**
>
> **"(4) contract with public or private agencies, institutions, and organizations, and with individuals . . .;**
>
> **"(7) collect and disseminate in cooperation with other Federal departments and agencies, and with other public or private agencies, institutions, and organizations having related responsibilities, basic data on chemical, physical, and biological effects of varying air quality and other information pertaining to air pollution and the prevention and control thereof; . . .**
>
> **"(f) (1) In carrying out research pursuant to this Act, the Administrator shall give special emphasis to research on the short- and long-term effects of air pollutants on public health and welfare. In the furtherance of such research, he shall conduct an accelerated research program— . . . (B) to improve knowledge of the short and long-term effects of air pollutants on welfare.**
>
> **"(2) In carrying out the provisions of this subsection the Administrator may . . . (C) utilize, on a reimbursable basis, the facilities of existing Federal scientific laboratories and research centers; (D) utilize the authority contained in paragraphs (1) through (4) of subsection (b); and (E) consult with other appropriate Federal agencies to assure that research or studies conducted pursuant to this subsection will be coordinated with research and studies of such other Federal agencies."**

EPA's research responsibilities, as outlined in the portions of the Clean Air Act cited above, constitute the Meteorological Laboratory's principal mission. The Laboratory also provides direct assistance in the evaluation of environmental impact statements.

> **"IMPLEMENTATION PLANS**
>
> **"Sec. 110. (a) . . . (2) The Administrator shall . . . approve or disapprove such (state-submitted implementation) plan or any portion thereof. The Administrator shall approve such plan, or any portion thereof, if he determines that it was adopted after reasonable notice and hearing and that— . . . (C) it includes provision for establishment and operation of appropriate devices, methods, systems, and procedures necessary to (i) monitor, compile and analyze data on ambient air quality . . ."**

Laboratory assistance provided by the Meteorological Laboratory in support of the evaluation and enforcement of state implementation plans by EPA is a component of Section 110 of the Clean Air Act.

> **"EMERGENCY POWERS**
>
> **"Sec. 303. Notwithstanding any other provision of this Act, the Administrator . . . may bring suit . . . to immediately restrain any person causing or contributing to (the) alleged pollution to stop the emission of air pollutants causing or contributing to such pollution or to take such other action as may be necessary."**
>
> **"ADDITIONAL REPORTS TO CONGRESS**
>
> **"Sec. 313 . . . the Administrator shall report to Congress on measures taken toward implementing the purpose and intent of this Act . . ."**

The Meteorological Laboratory provides direct support to EPA's exercise of emergency powers under Section 303 of the Clean Air Act. The Laboratory's assistance is also provided in support of Section 313 of the Clean Air Act to prepare meteorological portions of reports to Congress.

Table 13 contains a summary of the resources employed by ML for Fiscal Year 1974 in support of the applicable sections of the Clean Air Act.

ORGANIZATION

The Meteorology Laboratory consists of five Branches: Model Development, Environmental Applications, Climatic Analysis, Regional Air Pollution Study (RAPS), and Special Projects. The activities and research programs of these five Branches in furtherance of the Laboratory's mission are described briefly below.

Table 13. SUMMARY OF RESOURCES FOR METEOROLOGICAL LABORATORY FOR FISCAL YEAR 1974

Section of Clean Air Act supported	Funds, 10^3	Positions	Approximate percent
103	5940	49	94
110	275	12	4
303	36	–	1
313	50	–	1
Totals[a]	6301	61	100

[a] Does not include $0.5 million of special energy appropriations, but includes 47 positions loaned under interagency agreement with National Oceanic and Atmospheric Administration.

Model Development Branch

The Model Development Branch develops the analytical and numerical formulations (i.e., meteorological dispersion and statistical techniques models)

Solar tracking instruments are used to track the sun, measure the intensity of solar radiation, and indirectly provide a measure of atmospheric aerosol concentration.

that are used to estimate relationships between source emissions having any specified distribution and the resultant air quality throughout any specified region. The Branch also conducts theoretical and experimental studies to improve the understanding of physical processes affecting the transport, diffusion, transformation, and ultimate disposition of pollutants in and from the atmosphere.

Environmental Applications Branch

The Environmental Applications Branch evaluates new and existing meteorological dispersion and statistical techniques and models and adapts them to recurring user applications. The Branch maintains liaison with groups applying and developing models to provide guidance and advice and to ascertain future model needs at the user level.

Climatic Analysis Branch

The Climatic Analysis Branch develops and applies techniques of meteorological data analysis and presentation to provide information on the potential for atmospheric dispersion of air pollutants in a specific geographical area. The Branch determines empirical relationships between air quality data, meteorological parameters, physical processes governing observed air quality, and site characteristics. Through a national and international cooperative network, Branch personnel monitor atmospheric turbidity and establish seasonal values, geographical variations, and long-term trends. Field experiments are designed and conducted to determine the radiant energy balance of earth-atmosphere systems in both urban and rural locations. The Branch evaluates and studies the collected data by incorporating them into radiation transfer theories for variously polluted and clean atmospheres, and thereby establishes effects of pollutants on the energy balance, which then affects pollutant distribution.

Regional Air Pollution Studies (RAPS) Branch

The Regional Air Pollution Studies Branch develops, implements, and manages a comprehensive research program to define and describe air pollution transport and transformation processes in the atmosphere on a regional scale. It coordinates the activities of other agencies, both public and private, that are conducting field experiments pertinent to RAPS to ensure that the broad program of research, development, and field experimentation directed toward the acquisition, verification, and evaluation of basic data for models used to describe and predict the transport, dispersion, and concentration of pollutants in the regional area is conducted in an appropriate and economical manner.

Special Projects Branch

The Special Projects Branch provides continuing technical guidance and staff support to EPA components, including the Regional offices, to ensure that appropriate meteorological information is provided in abatement, compliance, and other operational activities. The Branch collects and evaluates environmental quality and meteorological-climatological information appropriate for application to power plant or industrial engineering requirements, design of monitoring networks, support of legal actions, and studies of possible effects of air pollution. In support of EPA Regional Offices, consultation and other meteorological assistance is provided to State and local air pollution control agencies. Field support is provided in air pollution emergencies. Liaison is maintained with the National Weather Service through participation in the work of interagency committees.

PHYSICAL FACILITIES

In addition to the usual meteorological instrumentation, the Laboratory possesses a mobile lidar (laser-radar) unit, a microwave thermosonde system, special meteorological sensors for studying surface energy fluxes, special equipment for sensing short- and long-wave radiation, and a small wind tunnel. The sunphotometers used in the national and international turbidity networks are tested, repaired, calibrated, and occasionally built in the Meteorology Laboratory. The Laboratory's small wind tunnel is used to physically demonstrate the dispersal of a pollutant from a scale-model source. A large, sophisticated wind tunnel is expected to be in operation by early 1975. This new device initially will be an open-return, non-stratified tunnel with a test section that is 3.66 meters (12 feet) wide, 2.13 meters (7 feet) high, and 18.29 meters (60 feet) long with a maximum air flow speed of 7.62 meters (25 feet) per second.

MAJOR PROGRAM AREAS

Meteorology Laboratory activities can be functionally divided into five areas: development, evaluation, and validation of air quality models; innovative development in air quality simulation models, determination of patterns and levels of pollutant emissions from large power plants, determination of pollutant and thermal emission effects on visibility, weather, and climate; and meteorological support for abatement and compliance efforts.

Unless indicated otherwise, the research activities discussed in the following paragraphs represent continuing efforts by ML or its contractors in support of Section 103 of the Clean Air Act.

Air Quality Models

Information on the meteorological effect of pollutant concentrations on prospective control strategy decisions and land-use plans is provided by models describing temporal and spatial variations in air quality. To facilitate the application of models, the air quality simulation models and related data for various pollutants are stored at a central computer facility, called the User's Network of Applied Models of Air Pollution (UNAMAP).

- APRAC–Provides the hourly average carbon monoxide level as a function of extraurban diffusion from automotive sources in upwind cities, intraurban diffusion from roadway sources, and local diffusion within a street canyon.
- HIWAY–Estimates highway-related air pollution for receptor locations that are downwind of at-grade and cut highway sections.
- CDM–Provides long-term average pollutant concentration.
- PTMAX Estimates the maximum hourly average ground-level concentration from a single stack as a function of stability and wind speed.
- PTDIS–Estimates the hourly average ground-level concentration from a single stack at a specified downwind distance.
- PTMTP–Estimates the average hourly concentration at up to 30 receptors from up to 25 sources.

Reactive pollutants and inert pollutants are the two major areas of concern in efforts to model transport and dispersion characteristics from single-line and area sources.

Reactive Pollutant Models

Three private research organizations under contract to ML developed separate air quality simulation models for reactive pollutants. Two of the models, one by Pacific Environmental Services (PES) and one by General Research Corporation (GRC), are quasi-lagrangian or "trajectory" models. These models follow an air parcel, a body of air within which chemical processes occur as the air moves over various emission sources. PES assumes that the atmosphere consists of a single well-mixed vertical layer between the surface of the earth and the top of the mixing layer; GRC assumes a multilayered vertical structure. PES uses a 33-reaction kinetic module; GRC uses a 16-reaction kinetic module. The basic difference between the two models lies in the handling of the hydrocarbon reactions.

System Applications, Inc. has developed a "grid" or Eulerian model that is basically a three-dimensional multi-box representation. This model divides the mixing layer into a maximum of 10 layers, the horizontal scale is 2 miles by 2 miles for a grid square. The 15-reaction kinetic module is similar to the GRC model.

In each of these three models the meteorological parameters are input; they are not predicted by the model. All three are single-day, daylight models and all are relatively crude first generation efforts.

Inert Pollutant Models

The Meteorology Laboratory's effort in inert pollutant modeling includes: modification and testing in the Los Angeles basin of the urban meteorology and pollutant model developed by the Center of Environment and Man; evaluation of Northern Engineering Research Corporation's airport model by Geomet, Inc., based on observations made at Washington National Airport, development and use of a computational procedure for estimating maximum 24-hour concentrations that occur once per year from a single power plant emitting pollutants from one to six stacks; initial development of a versatile short-term model for urban areas with a stagnation sub-model for use in episode control; development and use of a screening procedure to evaluate in broad terms the impact (relative to the air quality standard) of a point source releasing a nonreactive pollutant; evaluation by Geomet of a gaussian plume urban diffusion model; development and testing by Los Alamos Scientific Laboratory of a numerical model of air pollution transport in street canyons; and evaluation of an analytical and experimental study of diffusion in the turbulent surface layer.

Additional Modeling Work

Pennsylvania State University, under an EPA grant, conducted studies on the development of a three-dimensional meteorological and air quality prediction mesoscale model, on a parameterization scheme for incorporating the effects of sub-grid fluxes into a regional model, on the modeling of sub-grid turbulent transport applicable to microscale modeling of the urban environment, and on the interpretation of remote sensing data with emphasis on interpretation of acoustic radar signals to determine vertical wind and temperature profiles.

Stanford Research Institute conducted two studies: one to observe the photochemical smog over San Francisco by attempting to track an air parcel crossing San Francisco Bay; and the other, to measure the geophysical characteristics and energy budget of the urban surface in the St. Louis area.

A study of the dispersion, transport, and removal of airborne pollen was conducted by the State University of New York at Albany. Preliminary results suggest that source configuration and local meteorology are critical factors. The University of Wisconsin at Milwaukee is studying the transport of pollution by and within lake-breeze circulation.

In September and October of 1973, a field program—Los Angeles Reactive Pollutant Program (LARPP)—was conducted in the Los Angeles basin to obtain air quality and meteorological data for the development and evaluation of "trajectory" air quality simulation models for reactive pollutants. Work is also being conducted at the University of California at Los Angeles, using a wind tunnel, cloud chamber, and rain chamber, to determine the scavenging efficiencies of precipitation for atmospheric aerosols.

The first generation air quality simulation models for reactive pollutants previously mentioned and other existing photochemical models are being analyzed and evaluated. A second generation model that will include revision of the chemical reaction module, provision for multi-day simulation, inclusion of the sulfur reactions, and improvements in the meteorological components is under development.

Innovative Air Quality Models

New and improved concepts and methodologies for use in the development and evaluation of air quality simulation models having a broader, more comprehensive capability to predict the air quality distribution under various emission, topographic, and meteorological conditions are being developed. Among the technologies applied to the solution of practical problems will be the fluid modeling facility.

(The wind tunnel for the facility is currently under construction.)

Efforts, most of which are now in progress, include the development of a three-dimensional model of the wind and temperature field, as a function of time and space, in a region extending about 30 X 30 kilometers horizontally and 2 kilometers vertically. Currently, work on this model concerns: specifying boundary conditions that will allow nesting of the model in a larger scale model; incorporating a meaningful surface balance; and developing additional equations for the generation of turbulent dissipation and turbulent energy required for parameterizing the subgrid scale dynamics.

Aeronautical Research Associates of Princeton, Inc., under contract to EPA, is applying its invariant modeling concept to the analysis of diffusion under three conditions: in an unstable surface atmospheric layer capped by temperature inversion, from a point source in three spatial dimensions, and in the Ekman spiral of the planetary boundary layer.

Large Single-Source Models

The transport and dispersion characteristics of pollutants from large single sources have been studied and modeled. Field studies were conducted to provide data for the evaluation of plume dispersion models capable of calculating ground level concentrations of effluents from single sources with tall stacks. Information on the chemical transformation of pollutants within the plume was also collected to assist in modifying the plume dispersion models. These models will be used to determine the impact of large single sources on a region's air quality.

The large power plant effluent study (LAPPES) in Western Pennsylvania was completed in 1970. Analysis of the data is continuing, with current emphasis on the analysis of observed plume dispersion parameters. The observations were made in the vicinity of three large, coal-burning, mine-mouth power plants as each plant was constructed, came on-line, and went into full operation.

Preliminary work has been done on the problem of integrating the emissions from a large single-point source of reactive pollutants into an air quality simulation model for reactive pollutants in a region.

Field studies are underway in cooperation with the Tennessee Valley Authority (TVA) to measure chemical transformation in a fossil-fuel power plant plume. The study is concerned with the dispersion and interaction of sulfur dioxide, sulfuric acid, nitrogen oxide, ozone, and particulates in stack emissions from coal-fired power plants. Analysis of the data has begun.

By use of a water channel, Flow Research, Inc., under an EPA contract, is examining the effects of terrain features on the dispersion of plume pollutants. Initial work dealt with the dispersion of a plume in the vicinity of two hills joined by a saddle.

Climatic Effects

This work area encompasses the analysis of pollutant effects of physical processes in the atmosphere, the comprehensive examination and statistical analysis of air pollution meteorology parameters, and the assessment of the effect of meteorological and climatological parameters on air quality. Statistical, numerical, and experimental methods were used to investigate the effects of air quality on meteorology and climatology, and to assess the effects of meteorology and climatology on air quality.

Work in this area included: analysis of U.S. rawinsonde data to obtain meteorological data pertinent to the preparation of dispersion estimates for large single-point sources, initiation of an investigation to develop an objective technique for determining hourly mixing heights, and studies of atmospheric turbidity and urban radiation.

A study of the worst air stagnation episodes lasting 1, 2, 3, 4, and 5 days at 62 rawinsonde stations in the contiguous United States was conducted using mixing height and wind speed data covering a 5-year period. This information can be applied to models of atmospheric transport and diffusion processes during episodes of extremely slow dilution (air stagnation).

A turbidity network of 80 stations, 50 in the U.S. and 30 in other countries, is maintained by EPA. The instrumentation, instrumentation calibration, and instrument repair is provided by EPA. Data reduction and publication is performed by the National Oceanic and Atmospheric Administration (NOAA), with quality control assistance from EPA.

The difference in the radiation budget between rural and urban sites was examined in the St. Louis area. Observations were made of the incident global and direct solar radiation, of atmospheric turbidity, of downward-directed long-wave irradiance, and of the particle content of the atmosphere. Preliminary evaluation of the data indicates that 6.5 percent less total solar energy is received at the urban site than at the rural site.

An examination is underway to evaluate the relative importance of interurban and interregional transport of air pollutants and to identify the meteorological conditions associated with significant long-distance transport (greater than 100 kilometers).

Meteorology Support

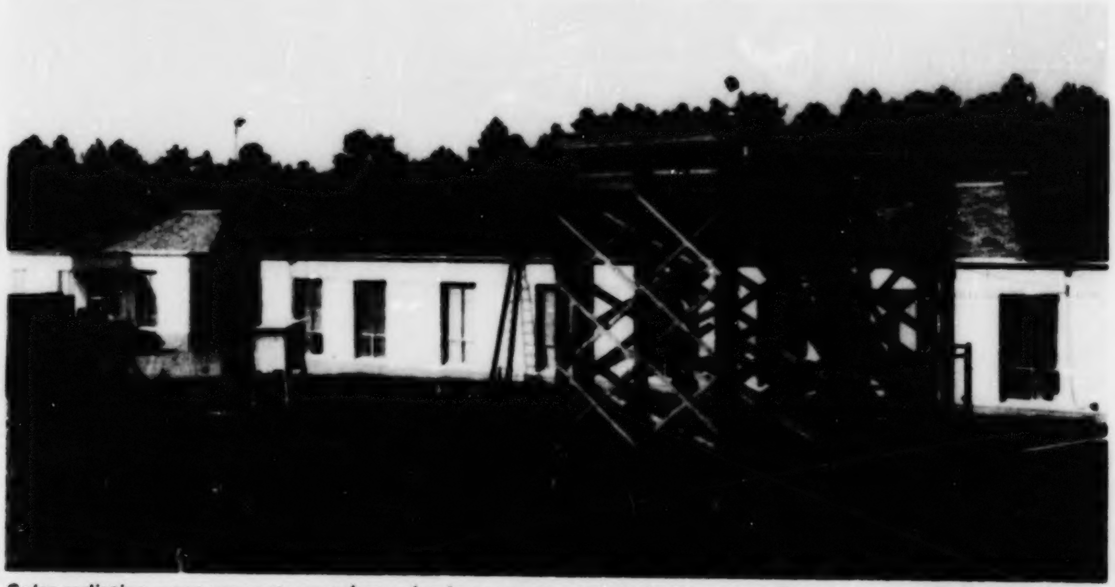
In support of Sections 110, 303, and 315 of the Clean Air Act, Meteorology Laboratory provides technical services to various EPA offices and programs, and to State and local agencies. The Laboratory also supplies meteorological field support to EPA's Emergency Team during critical air pollution incidents, such as the chloride barge accident at Morgan City, LA. NOAA meteorologists were assigned to the Monitoring and Data Analysis Division and the Control Programs Development Division of EPA's Office of Air Quality Planning and Standards and to the Quality Assurance and Environmental Monitoring Laboratory and the Human Studies Laboratory of NERC-RTP.

OAQPS Support

During 1973, the Laboratory provided meteorological support for three major studies conducted by OAQPS. First, the impact of smelting operations on sulfur dioxide concentrations in the Rocky Mountain area was examined. Second, the effects of granting variances to large, non-urban power plants, if ambient air quality standards were not violated, were examined. Results of applying ML's 24-hour single-source model to three Air Quality Control Regions in Indiana indicated that large power plants could be allowed to burn coal temporarily at the 1970 sulfur levels without violating either annual or 24-hour primary ambient air quality standards. Third, an investigation of possible intermittent control systems showed that such systems were viable control measures, but only for large, isolated, elevated sources of sulfur dioxide.

In addition to reviewing Environmental Impact Statements and providing expert testimony in court suits, ML personnel assigned to OAQPS analyzed air quality trends using data from the National Aerometric Data Bank. Initial trend analysis focused on isolating meteorological parameters that may cause short-term trends. Thus far only heating degree-days and rainfall have been associated with the short-term trends. A trend toward increasing suspended particulate levels was found to be associated with decreased rainfall between 1968 and 1971 in the western states.

Two meteorologists, assigned to the Air Pollution Training Institute presented the meteorological portions of the Institute's courses. In addition, they conducted three courses during the year: Air Pollution Meteorology, Diffusion of Air Pollution—Theory and Application, and Meteorological Instrumentation in Air Pollution. They also conducted a 2-week training course for NOAA meteorologists responsible for preparing Air Stagnation Advisories.



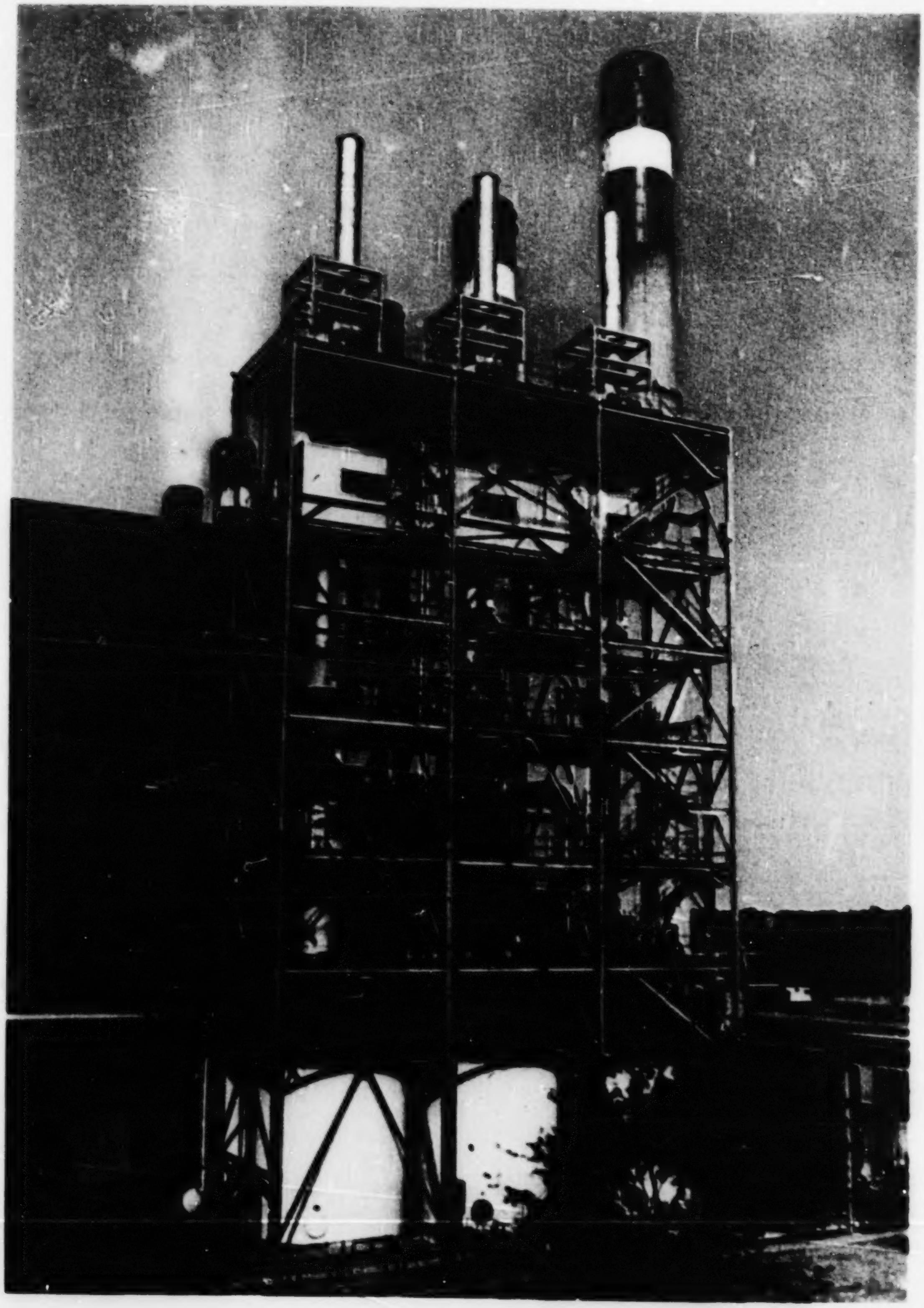
Solar radiation measurements are taken using instruments mounted on a meteorological tower near the Meteorological Laboratory. A crank-up tower and a temperature shelter can be seen to the left of the tower.

NERC-RTP Support

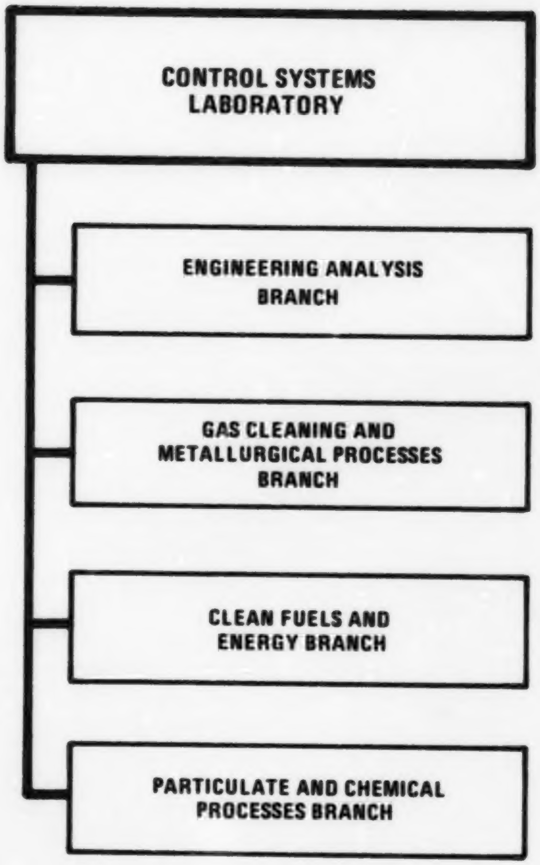
Atmospheric turbidity is measured using a portable sunphotometer developed at Meteorology Laboratory.

Meteorological personnel assigned to other laboratories within NERC-RTP provide assistance and guidance on meteorological and climatological criteria and instrumentation. In audition, daily summaries of atmospheric stagnation conditions were prepared for the Community Health and Environmental Surveillance Study (CHESS) in New York, NY; Birmingham, AL; Charlotte, NC; and Los Angeles, CA. A prototype continuous monitoring station was installed at Chapel Hill, NC, to determine the best instrumentation for measuring temperature, dewpoint, and wind velocity. This instrumentation will be part of the Community Health Air Monitoring Program (CHAMP). Climatological assistance was provided for an asthma study in southern California. Studies are underway on the relationship between mortality statistics and maximum temperatures, and the relationship between extremely high nitric oxide and nitrogen dioxide concentrations in Chattanooga, TN, and atmospheric conditions in the area.

Control
Systems
Laboratory



Control Systems Laboratory


CONTROL SYSTEMS LABORATORY
ENGINEERING ANALYSIS BRANCH
GAS CLEANING AND METALLURGICAL PROCESSES BRANCH
CLEAN FUELS AND ENERGY BRANCH
PARTICULATE AND CHEMICAL PROCESSES BRANCH

Studies of the operation of lime/limestone flue gas scrubbing processes are conducted at a prototype test facility by the Control Systems Laboratory. The facility (TVA's Shawnee Steam Plant, Paducah, Kentucky) employs three types of 10-MW equivalent scrubbers: the hydrofilter, the turbulent contact absorber, and the venturi.

OVERVIEW OF CSL'S MISSION

The Control Systems Laboratory (CSL) of NERC-RTP is involved in a variety of technical and management functions directly related to the research, development, and demonstration of equipment and systems designed to abate, in a timely and cost-effective manner, the emission of atmospheric pollutants from stationary sources to a level that protects public health and welfare, and to do so within the framework of our nation's energy and environmental mandates. Included in this mission is the goal of developing a complete data base of stationary source emissions and demonstrating adequate technology to control pollutant emissions so that effective New Source Performance Standards and Hazardous Pollutant Standards can be promulgated.

CSL has a high degree of expertise in the management of complex engineering research and development projects; additionally, as the result of 10 years of experience as an organizational entity, the Laboratory has developed other major capabilities in efforts to fulfill its mission:

- The Laboratory has established a technical information data base to support EPA's decision-making capabilities in the area of stationary source air pollution control.
- The Laboratory has proven its ability to reconcile environmental and industrial requirements in a cost-effective manner by working with industry on joint programs to solve environmental problems.
- The Laboratory has become an international forum for communication concerning available technology through its recognized ability to objectively evaluate new concepts and to share research results.

LEGISLATIVE MANDATE

The legislative mandates upon which CSL's several programs are based and the various Sections of the Clean Air Act requiring Laboratory support are shown below with a brief description of the types of actions taken to support that mandate or Section.

"RESEARCH, INVESTIGATION, TRAINING, AND OTHER ACTIVITIES

"Sec. 103. (a) The Administrator shall establish a national research and development program for the prevention and control of air pollution and as part of such program shall—

"(1) conduct and promote the coordination and acceleration of research, investigations . . . demonstrations, surveys, and studies relating to the causes, effects . . . prevention, and control of air pollution. . . .

> "(b) In carrying out the provisions of the preceding subsection, the Administrator is authorized to—
>
> "(1) collect and make available, through publications and other appropriate means, the results of and other information . . . pertaining to such research. . . .
>
> "(B) develop effective and practical processes, methods, and prototype devices for the prevention or control of air pollution."

In support of Sections 103 (a) and (b) of the Clean Air Act (cited above), CSL conducts studies and investigations to characterize emissions of pollutants, to evaluate control technology, and to predict the impact of and need for controls in the future. The Laboratory conducts research to develop cost-effective controls for pollutants from stationary sources and demonstrates the most promising control methods. Finally, CSL disseminates the research, development, and demonstration results to the public through seminars, professional meetings, and appropriate publications.

> "RESEARCH RELATING TO FUELS AND VEHICLES
>
> "Sec. 104. (a) The Administrator shall give special emphasis to research and development into new and improved methods, having industry-wide application, for the prevention and control of air pollution resulting from the combustion of fuels. In furtherance of such research and development he shall—
>
> "(1) conduct and accelerate research programs directed toward development of improved low-cost techniques for—
>
> "(A) control of combustion byproducts of fuels,
>
> "(B) removal of potential air pollutants from fuels prior to combustion,
>
> "(C) control of emissions from the evaporation of fuels,
>
> "(D) improving the efficiency of fuels combustion so as to decrease atmospheric emissions, and
>
> "(E) producing synthetic or new fuels which, when used, result in decreased atmospheric emissions.
>
> "(2) provide for Federal grants . . . and contracts . . . for payment of (A) . . . cost acquiring . . . for research and development purposes, new or improved devices or methods having industry-wide application of preventing or controlling discharges into the air of various types of pollutants. . . .
>
> "(3) determine, by laboratory and pilot plant testing, the results of air pollution research and studies in order to develop new or improved processes and plant designs to the point where they can be demonstrated on a large and practical scale;
>
> "(4) construct, operate, and maintain, or assist in meeting the cost of . . . new or improved demonstration plants or processes which have promise of accomplishing the purposes of this Act. . . ."

Through efforts provided for under Section 104 (a) of the Clean Air Act (cited above), CSL has brought flue gas cleaning to the stage of commercial development, has developed techniques for the reduction of nitrogen oxide (NO_x) emissions from combustion processes by as much as 50 percent; has currently under demonstration a commercially feasible means of reducing carbon monoxide, hydrocarbon, and particulate emissions from coke ovens by 90 percent; has identified promising new combustion techniques such as the advanced power cycle and fluidized-bed combustion; and has developed effective, low-cost processes for cleaning coal.

> "AIR QUALITY CRITERIA AND CONTROL TECHNIQUES
>
> "Sec. 108 . . . (b) (1) Simultaneously with the issuance of criteria under subsection (a), the Administrator shall . . . issue . . . information on air pollution control techniques, which information shall include data relating to the technology and costs of emission control. Such information shall include such data as are available or attainable technology and alternative methods of prevention and control of air pollution. Such information shall also include data on alternative fuels, processes, and operating methods which will result in elimination or significant reduction of emissions."

In support of Section 108 (b) of the Clean Air Act (cited above), CSL is continually evaluating new and existing stationary source control procedures in an effort to develop and maintain a comprehensive data base related to air pollution control techniques.

> "(STATE) IMPLEMENTATION PLANS
>
> "Sec. 110. (a) (1) Each State shall . . . adopt . . . a plan which provides for implementation, maintenance and enforcement of such primary (and secondary) standard. . . .
>
> "(a) (2) (B) it (the plan) includes emission limitations, schedules, and timetables for compliance. . . .
>
> "(e) (1) Upon application of a Governor . . . the Administrator may . . . extend (compliance period) . . . if . . . the Administrator determines that—
>
> "(A) One or more emissions sources . . . are unable to comply with . . . standard because the necessary technology or other alternatives are not available. . . .
>
> "(f) (1) . . . The Governor . . . may apply to the Administrator to postpone the applicability of such requirement to such source. . . . If the Administrator determines that—
>
> "(B) such source (or class) is unable to comply with such requirement because the necessary technology or other alternative methods of control are not available or have not been available for a sufficient period of time . . .
>
> "(D) . . . then the Administrator shall grant a postponement of such requirement."

The Laboratory's role in the procedures required by Sections 110 (a), (e), and (f) of the Clean Air Act (cited above) is primarily that of providing expert testimony relating to the availability of air pollution control technology. CSL's research, demonstration, and other evaluation tools provide the most comprehensive data base available concerning the state-of-the-art of air pollution control technology.

> **"STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES**
>
> **"Sec. 111. (b) (3) The Administrator shall, from time to time, issue information on pollution control techniques for categories of new sources and air pollutants. . . .**
>
> **"(d) (1) . . . each State shall submit to the Administrator a plan which (A) establishes emission standards for any existing source for any air pollutant. . . ."**

CSL, in support of Sections III(b) and (d) of the Clean Air Act (cited above), evaluates the state-of-the-art of air pollution control technology for various stationary sources and, based on projected future control needs, develops new control technology. The predicted new developments and schedules provide a basis upon which EPA can set future New Source Performance Standards. For non-criteria pollutants, the Laboratory's data base related to control capability and emission levels provides a basis upon which States may set emission standards for any pollutant from stationary sources.

> **"NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS**
>
> **"Sec. 112. (b) (2) The Administrator shall, from time to time, issue information on pollution control techniques for air pollutants subject to the provisions of this section.**
>
> **"(c) (2) The President may exempt any stationary source . . . if he finds that the technology to implement such standards is not available. . . ."**

In support of Sections 112 (b) and (c) of the Clean Air Act (cited above), CSL's programs will identify all air pollutants from stationary sources. As the need for control of these pollutants is indicated, through its related research and development program, the Laboratory will be able to identify not only the specific sources requiring control, but also the most cost-effective approach for achieving that control.

> **"COMPREHENSIVE ECONOMIC COST STUDIES**
>
> **"Sec. 312. (a) . . . The Administrator . . . shall make a detailed estimate of the cost of carrying out the provisions of this Act . . . and a comprehensive study of the economic impact of Air Quality Standards on the Nation's industries, communities, and other contributing sources of pollution, including an analysis of the national requirements for and the cost of controlling emissions to attain such standards of air quality. . . ."**

Among the activities of the CSL, related to Section 312 (a) of the Clean Air Act (cited above), are research and demonstration projects leading to the development of comprehensive data relating to the cost of various air pollution control techniques.

Because CSL's programs simultaneously support numerous sections of the Clean Air Act, it is impossible to allocate a given resource to only one Section of the Act. For example, a CSL flue gas cleaning demonstration project supports Section 103 (Research, Investigation, Training, and Other Activities); Section 104 (Research Relating to Fuels and Vehicles); Section 108 (Air Quality Criteria and Control Techniques); Section 110 (State Implementation Plans); Section III (Standards of Performance for New Stationary Sources—in this case for electric utilities); and Section 312 (Comprehensive Economic Cost Studies).

Thus, although Table 14 does not display a direct one-to-one relationship between projects and individual sections of the Clean Air Act, it does convey the general level of support that CSL's program provides to various sections of the Act.

Table 14. SUMMARY OF RESOURCES FOR CONTROL SYSTEMS LABORATORY FOR FISCAL YEAR 1974

Section of Clean Air Act supported	Funds, $\$10^3$	Positions	Approximate percent
103	4,030	24	25
104	3,546	21	22
108	1,934	11	12
110	1,934	11	12
111	3,675	22	22.8
112	967	6	6
312	32	–	0.2
Totals[a]	16,118	95	100

[a] Total is for CSL's "base program"; it does not include approximately $10.2 million of supplemental energy research and development funds received during FY 1974.

ORGANIZATION

The Control Systems Laboratory consists of four main Branches. Its Engineering Analysis Branch functions as a program monitoring and evaluation group. The other three Branches are engaged in projects ranging from small-scale experimental studies and exploratory research, through pilot-plant-size experimental work, to prototype evaluations of equipment large enough to permit confident scale-up to full-size commercial installations.

Gas Cleaning and Metallurgical Processes Branch

The Gas Cleaning and Metallurgical Processes Branch directs and manages a broad-based research, development, and demonstration program aimed at developing processes and equipment for the removal of gaseous pollutants from fossil-fuel combustion effluents and of all pollutants from primary and secondary operations in the ferrous and non-ferrous metals processing industries.

Much of the work of this Branch relates to flue gas scrubbing processes: lime/limestone wet scrubbing, at both TVA's Shawnee Plant and in Key West; double alkali scrubbing, using a soluble alkali (usually sodium) solution; Chemico Mag-Ox, a regenerable approach utilizing magnesium oxide; Wellman-Lord, utilizing a sodium sulfite/bisulfite solution with thermal regeneration; Stone and Webster/Ionics, utilizing sodium hydroxide solution with electrolytic regeneration; Monsanto Cat-Ox, a catalytic oxidation adaptation of the contact sulfuric acid process; and a completely cyclic ammonium sulfite/bisulfite process with bisulfate regeneration. The Branch's metallurgy-related activities include such iron and steel industry areas as coke ovens, sinter plants, basic oxygen process (BOP) furnaces, and iron foundry cupolas, as well as work with pollutants from copper, lead, and zinc smelters.

Clean Fuels and Energy Branch

The Clean Fuels and Energy Branch is responsible for research, development, and demonstration (including evaluation) studies relating to processes for the production or utilization of clean fuels or clean energy as a means of air pollution control. Among its activities are: evaluation of systems for removing potential pollutants from coal and oil; critical air pollutant emission assessment and review of new energy technologies; development of generalized control technology for air pollutant emissions from fossil fuel combustion and conversion processes; evaluation and development of combustion modifications for abating the emission of nitrogen oxides and other combustible pollutants from all stationary combustion sources; and evaluation, environmental assessment, and/or development of new pollution-free methods of generating and utilizing energy.

Combustion modifications for the control of nitrogen oxides and other pollutants have been (and continue to be) the target of significant efforts of Branch personnel. Modifications being investigated include: combustion with low excess air, recirculation of flue gas, staged combustion, combustor redesign, and fluidized-bed combustion. Investigations of fuel cleaning have included fossil fuels (coal, oil, and gas) and waste products such as municipal refuse.

Particulate and Chemical Processes Branch

The Particulate and Chemical Processes Branch is active in three major areas: it identifies, develops, and demonstrates generalized particulate control technology to support the needs of CSL for technology to control patriculate emissions from specific industries; it identifies, develops, and demonstrates technology for controlling pollutant emissions from the chemical process industries; and it provides process measurement services to all CSL Branches.

The Branch's work in the area of particulate control technology development has included studies not only to improve such conventional particulate control equipment as electrostatic precipitators, fabric filters, and wet scrubbers, but also to identify and further develop such completely new control approaches as the Sonic Agglomerator, Steam-Hydro Scrubber, and Pentapure Impinger. Its activities related to the control of air pollution from chemical process industries include studies of a wide range of organic and inorganic manufacturing processes, combustion processes, and open sources. The Branch's process measurement activities encompass the selection, verification, and further development of sampling methods, analytical procedures, and process instrumentation required for CSL's internal and external research, development, and demonstration activities.

Engineering Analysis Branch

The Engineering Analysis Branch is the Laboratory's program planning and evaluation coordination facility. Additionally, it is responsible for technical and editorial services that are more effective when they are provided centrally. Branch personnel provide cost control and contract management services to individual project officers and assist in the evaluation of unsolicited proposals as well as in the review of on-going programs. Staff specialists are available for consultation on specific technical matters.

PHYSICAL FACILITIES

Final relocation of all CSL personnel to NERC-RTP from several scattered locations was effected by the end of the fiscal year. CSL's laboratory facilities include a flue-gas generator; bench-scale scrubbing equipment; laboratories for odor problem studies and for the physical characterization of particulates; an electronics shop; and equipment for wet and instrumental analyses. CSL also maintains and operates a self-propelled van and a trailer (both 40 feet in length) that are equipped to conduct full-scale investigation of process streams.

Pilot-size equipment in the NERC-RTP High Bay Areas (Wings G and H-300) includes a model wet scrubber; four baghouses for fabric filtration studies; a laboratory for the evaluation of novel particulate control devices; and a variety of experimental and commercial combustion systems including furnaces, boilers, and a gas turbine instrumented for most gaseous pollutant emission measurements. (Fuels being investigated are coals, oils, gases, and other liquid and gaseous materials.)

The Laboratory's in-house capability to support measurements programs recently took a significant step forward with the installation, at NERC-RTP, of the first aerodynamic test facility specifically designed for studies requiring large gas volumes (up to 15,000 cfm) with carefully controlled velocity profiles and known chemical composition.

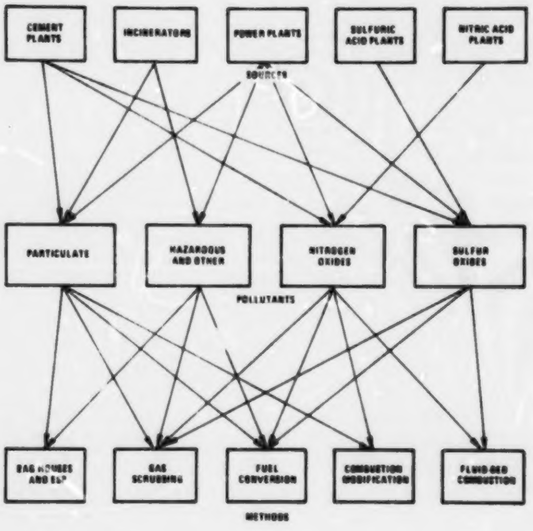
MAJOR PROGRAM AREAS

The accompanying diagram, showing air pollution control technology interactions, presents an overview of the Control System Laboratory program. Because of the way various laws are written, and because of EPA's planning system, CSL's program is divided into elements based on the control of individual pollutants. Obviously, however, to control ambient concentrations of pollutants, the industries producing the pollutants must be controlled.

The first five industries to which New Source Performance Standards were applied are shown at the top of the diagram. The methods that CSL is improving or developing for air pollution control are shown at the bottom of the diagram. Inevitably, there is significant overlap between industry, pollutant, and control method descriptions of CSL's program. For example, work directed toward controlling sulfur oxides (SO_x) may involve clean fuels, gas scrubbing, or advanced power cycles. On the other hand, SO_x gas scrubbing may be applicable to power plants, sulfuric acid plants, and non-ferrous smelters; and smelters may emit trace hazardous elements as well as SO_x.

For purposes of discussion, this portion of the Report is organized by control of specific pollutants. The broad applicability of a control method for more than one pollutant, from more than one source, should be kept in mind when analyzing the program. This interdependence of CSL program components highlights an important synergistic characteristic: for example, a change in the Laboratory's combustion control research program, to reflect changes in the nitrogen oxides (NO_x) program philosophy, will also affect CSL's program to control combustible particulates—particulates which may include carcinogenic hydrocarbons, possibly the most hazardous of pollutants.

A strong cooperative effort has been fostered between industry and government: CSL's major control technology development/demonstration projects have been cost-shared approximately equally by both sectors. Industrial studies conducted by the Laboratory have resulted in initiation of such promising projects as various flue gas desulfurization systems, advanced power cycles, low-Btu gasification, and coke pushing and charging demonstrations. Because many aspects of air pollution control are nearly equal in importance, CSL's efforts are not (and cannot be) concentrated in any single area.



Air pollution control technology interactions among sources to which new source performance standards were first applied.

Particulate Control

The most pressing need in particulate control technology is the development of commercially available and widely applicable fine particulate (micrometers in diameter) control technology to support the establishment of Fine Particulate Ambient Air Quality Standards. Such technology is generally inadequate and currently in the early stages of development under EPA sponsorship. This technology is also acutely needed to achieve Hazardous Pollutant Standards and associated New Source Performance Standards for trace metals, which have already been established or are planned for the near future. In an effort to develop this technology as rapidly as possible, CSL is currently working with many (nearly 70) contractors, grantees, and consultants.

Scrubbers, electrostatic precipitators, and fabric filters are currently the major particulate collection devices. These devices are being up-graded by projects concerned with decreasing costs, increasing applicability of these devices to a wider range of sources, and extending their range of particle collection capability to smaller particle sizes. In addition, entirely new concepts of particle collection are being investigated.

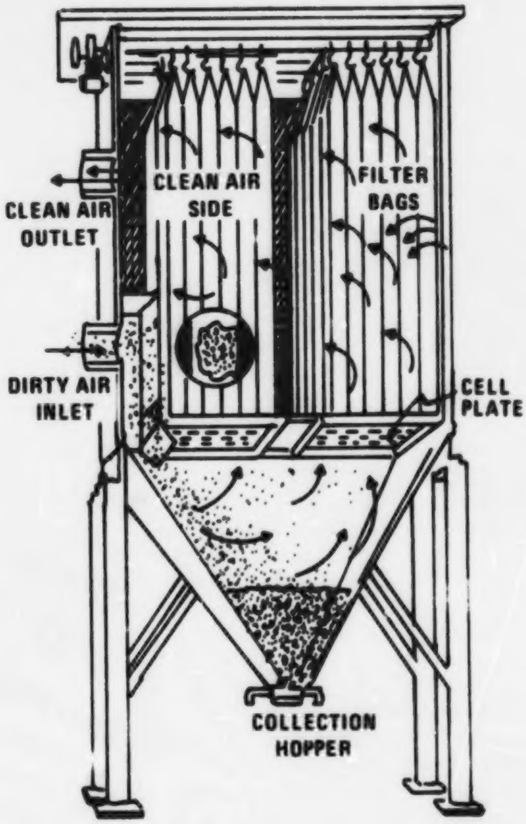
System studies, completed for each of the conventional devices, define potential areas of improvement and new applications. Long range projects include: development of generalized models for existing collectors, identification and laboratory scale testing of totally new concepts in particle control technology, and pioneering work in small particle detection and small particle generation equipment.

Electrostatic Precipitation—In an electrostatic precipitator (ESP), dust suspended in the gas stream is electrically charged and passed through an electric field where electrical forces cause the particles to migrate toward a collection electrode. The dust, separated from the gas by being retained on the collection electrode, is subsequently removed from the device. In a conventional ESP, the dust is removed mechanically. In a wet ESP, the dust is removed by continuous washing of the collection electrode.

CSL is conducting field tests of industrial ESP's to determine the fine particle collection efficiency and economics of ESP systems. Recent results indicate that properly designed and operated ESP's are capable of controlling flyash from coal-fired utility boilers at an overall mass efficiency in excess of 99 percent. These same efficiency measurements indicate that these ESP's are more than 90 percent efficient on a mass basis in collecting all particle size fractions down to about 0.01 micrometer in diameter.

ESP's are being redesigned to improve their particulate collection efficiency, especially for fine particles and high resistivity dusts. This work includes development of special dust-conditioning methods, particle charging procedures, and collection section designs. The work on conditioning has resulted in the discovery of the current-carrying mechanism in flyash at high temperatures and the demonstration of a new conditioning agent.

Fabric Filtration—A typical fabric filter consists of a flexible layer of porous cloth through which a dust-laden gas is passed to separate particles from the gas stream. Fabric filters have been used successfully for many years to collect dusts at temperatures as high as about 290°C; however comparatively little scientific effort has been expended to develop higher temperature filtration technology. Fabric filtration is one of the few techniques now capable of collecting very small particulate matter. Fabric filters are usually flat or tubular bags suspended in a structure known as a baghouse (see accompanying figure).



Typical fabric filter baghouse.

One product of a fabric filter systems study, completed for CSL in 1970, is a technology handbook intended as a guide in the design, development, application, and operation of fabric filter systems. The study also recommended research and development for possible funding by EPA.

Products of that research over the period of this Report have been publications that relate woven fabric structure to filtering performance and evaluate new spunbonded nylons as filter media. Experimental work to aid in selecting optimum filter cleaning methods has been completed: a report of that work will be issued late in 1974.

Major effort has been directed toward characterizing and improving fabric filter system performance for capture of fine particulates. Tasks in this area have been awarded to contractors and grantees, as well as being pursued in-house. Specific programs involve the development of non-woven media; the development of high-velocity, high-efficiency filtration techniques; and the construction of a portable baghouse system for on-site field testing.

Novel Particulate Collection Devices—The cost of high-efficiency particle collection from industrial sources by conventional equipment of all types (scrubbers, filters, ESP's) is high, in large part because the efficiency of most collectors decreases in the fine particulate range. This performance loss must, therefore, be offset by large size or high-energy input. Devices or systems based on new collection principles or on radical redesign of conventional collectors are sometimes offered by private developers. Presently proposed systems include sonic agglomeration, granular bed filtration, foam scrubbing, and several types of steam or high-pressure water ejector scrubbers. Entirely new concepts utilizing new mechanisms have the potential for providing high-efficiency fine particle collection or for permitting the growth of particles by agglomeration for subsequent more efficient collection. New concepts that have been advanced include charged droplet scrubbing and collection of charged particles by fiber beds.

All known novel devices and new collection concepts are being reviewed by EPA. Those showing potential for fine particle collection will be evaluated for performance and related cost. Systems showing promise of high-efficiency fine particle collection at reasonable cost and meriting further development will, if necessary, be further supported by CSL.

Wet Scrubbing—In a wet scrubber, both gaseous and particulate pollutants are transferred from the gas to the scrubbing liquid. The availability of a wide variety of scrubber types and scrubbing liquids gives wet scrubbers the potential for satisfactorily removing many pollutants.

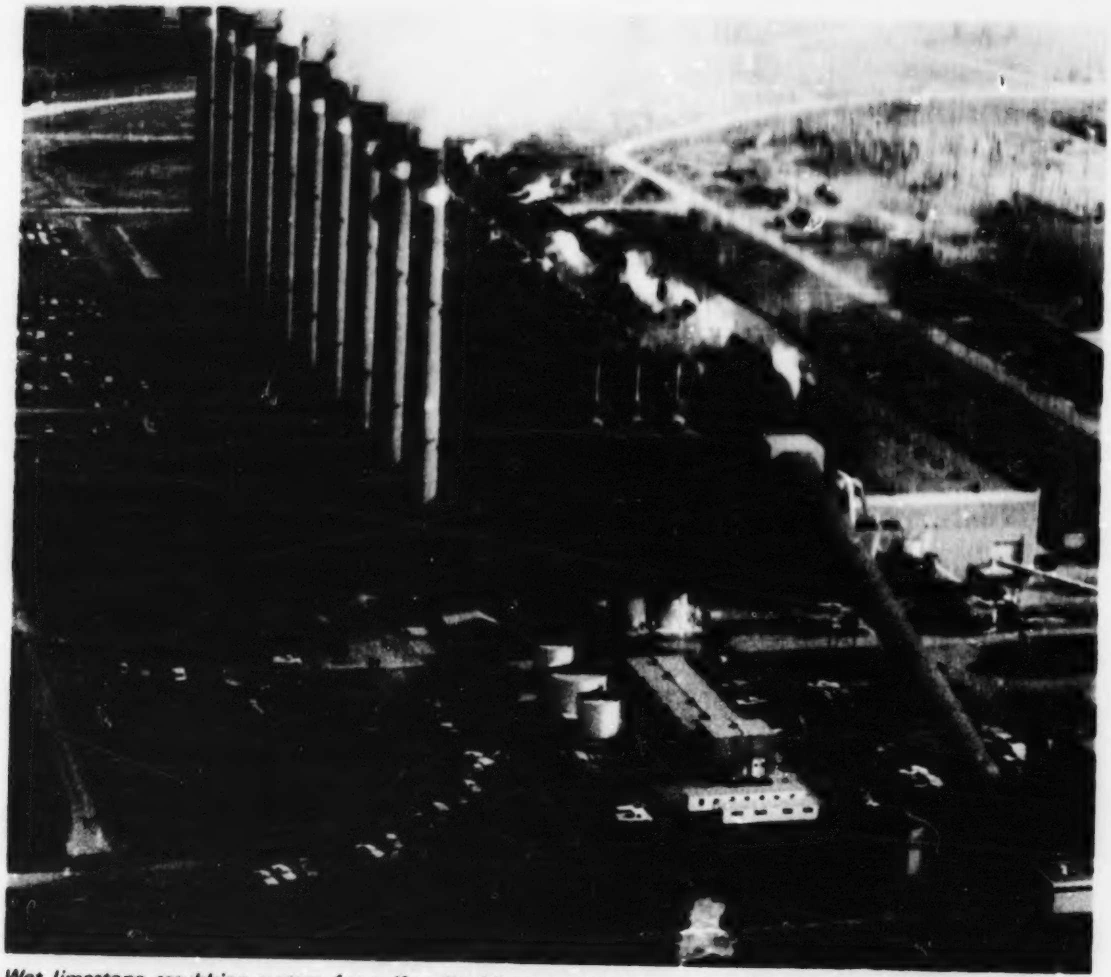
Sulfur Oxides Control

In the area of sulfur oxides (SO_x) control, achievement of Ambient Air Quality Standards demands the control of industrial combustion, industrial processes, and area sources, as well as utility combustion. Natural low-sulfur fuels are only sufficient to satisfy about 40 percent of the demands of State Implementation Plans. The remainder must be supplied by control technology in the form of effluent desulfurization, fuel cleaning, or process modification. Although the currently defined SO_x control technology program contains developmental projects of sufficient diversity to ensure the achievement of Ambient Air Quality Standards, a substantial EPA research and development investment will be required to bring this technology to commercial fruition. Only in the case of effluent desulfurization technology for electric utility applications will the control technology achieve widespread commercialization within the next few years.

Consistent with Congressional guidelines, CSL's major concern has been the control of sulfur oxides from fuel combustion. About 80 percent of the Laboratory's total expenditures to date have been in this area and have been concentrated on flue gas cleaning. Flue gas cleaning devices are now being installed on commercial power plants in this country. The prototype demonstrations that CSL has underway are shown in Table 15. Except for clean fuels, flue gas cleaning is probably the only sulfur oxides control technique that will have widespread application within the next 10 to 15 years. With the expected shortage of clean fuels (amounting to about

Table 15. PRESENT AND PROJECTED FLUE GAS CLEANING DEMONSTRATIONS

Process and application	Startup	Removal efficiency, %
Wet limestone scrubbing Shawnee-TVA (30 MW, coal)	April 1972	75-90
Key West (40 MW, oil)	January 1974	60-80
MgO scrubbing (Chemical: 155 MW, oil)	May 1972	85-90
Cat-OX (Monsanto: 100 MW, coal)	June 1972	85-90
Wellman-Lord (115 MW, coal)	July 1975	90-95
Stone & Webster/Ionics (70 MW, coal)	November 1975	90-97



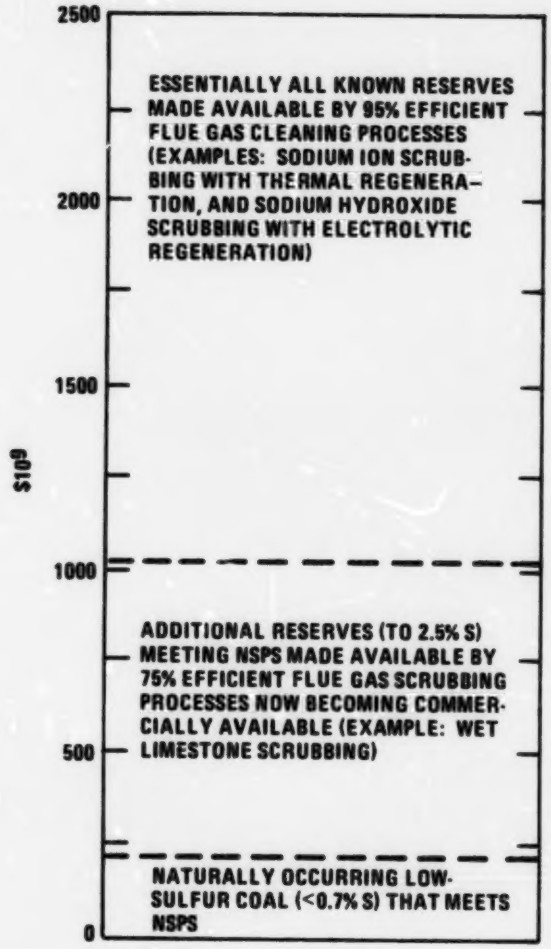
Wet limestone scrubbing system for sulfur dioxide removal is in operation at TVA's Shawnee coal-fired power plant in Paducah, Ky.

20 percent of the coal demand), flue gas cleaning should find wide application.

The need to develop techniques to permit the use of eastern and midwestern coal is shown clearly in the accompanying figure. Only about 7 percent of this coal is usable under New Source Performance Standards. Because of physical and contractual limitations it is not possible to mine all the low sulfur coal first. (That is, the mining will proceed from left to right, not from bottom to top.) Thus a native resource approximating the GNP will not be available for use if cleaning techniques are not utilized. It had been projected that this would cause economic dislocations and unemployment, substantial increase in the flow of dollars outside the country, and increased dependence of the security of our country on mid-eastern oil; current events substantiate that projection.

Flue gas cleaning provides an economical and available solution to this problem. A typical annualized cost for control of a new, large, coal-fired power plant would be equivalent to a fuel premium of 18¢/10^6 Btu, and for oil, 13¢/10^6 Btu. Approximately 50 percent of the coal-fired power plants could be retrofitted at a cost equivalent to 20¢/10^6 Btu fuel premium, compared to a 35¢ to 50¢/10^6 Btu premium on clean fuels.

Most of CSL's early coal desulfurization work was in the area of improving and evaluating physical cleaning methods for coal. With the overall potential of physical desulfurization and deashing of coal reasonably well established, this approach should have moderate applicability in reducing sulfur by 30 to 70 percent in specific coals. Ongoing work in this area includes washability testing, coal desulfurization



Value of eastern and central coals meeting new source performance standards as a function of efficiency of flue gas cleaning processes (value of coal resources at $4 per ton).

and cleaning, and pollutant control evaluation and optimization. The most recent work is aimed at chemical desulfurization of coal and the problems of hazardous pollutants in fossil fuel.

Two factors—the major contribution of small coal- and oil-burning sources (area sources) to the degradation of ambient air quality and the severely limited supplies of low-sulfur fuels—indicate a need for clean fuel or coal conversion processes. CSL has provided funds to both the Bureau of Mines and the Office of Coal Research to assist in both the development of conversion and gasification processes that can provide clean fuels and the determination of environmental controls that will be required for these techniques.

Since 1967, CSL has been actively developing several versions of the fluidized-bed process for combustion of coal and residual oil as a means of economical pollution control in low cost steam and power generation. This combustion process has the capability of reducing pollutant emissions 95 percent for SO_2, 80 percent for NO_x, and 99 percent for particulates. In addition, the capital costs for such a plant would be 10 to 20 percent less than a conventional facility, and thermal discharge to watercourses can be reduced by 10 to 60 percent. Fluidized-bed combustion represents an attractive long-range solution to the control of pollutants from utility boilers.

The Laboratory is also conducting research into the control of emissions from smelters, iron and steel operations, kraft wood pulping mills, iron foundries, secondary aluminum furnaces, and other industrial sources of SO_x.

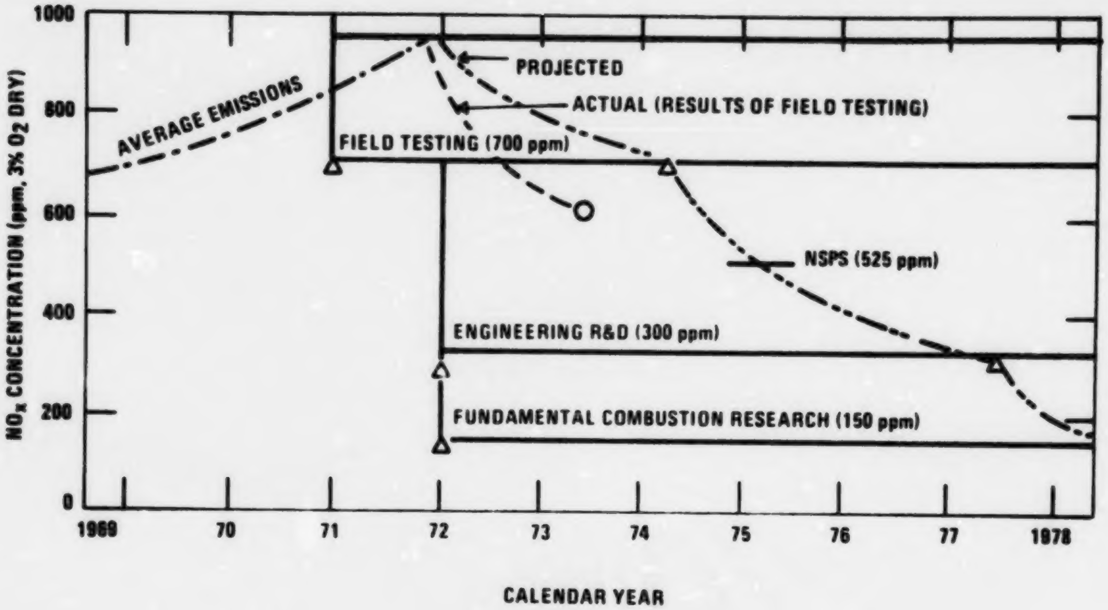
Nitrogen Oxides Control

On a National basis, 65 percent of the emissions of nitrogen oxides (NO_x) are from combustion sources other than motor vehicles. For this reason, the CSL program is oriented heavily in the direction of combustion control. Control of stationary sources of NO_x will be necessary for achieving and maintaining Ambient Air Quality Standards as well as for establishing future New Source Performance Standards.

The main approach has been modification of the combustion process to reduce NO_x formation. Bench-scale work and field testing indicate that necessary control for the immediate future can be achieved by this method. In addition, stack gas cleaning processes are being evaluated and investigated on a small scale; results in this area, however, are not encouraging thus far.

A further complication in nitrogen oxides formation is that not only is nitrogen fixed in the air, but also some fuel nitrogen is converted to nitrogen oxides. Some success in controlling NO_x from fuel nitrogen has been achieved, however. Whether control of fuel nitrogen by combustion modification alone will be adequate has not yet been determined.

The accompanying figure shows another area in which CSL has made a major contribution—nitrogen oxides control in coal combustion, the most difficult area. The field testing program, which has been underway since the beginning of calendar year 1971, has been more effective than anticipated and is substantially ahead of schedule. The second part of



Control of nitrogen oxide emissions from coal-fired utility boilers.

the NO$_x$ program, engineering research and development began in calendar year 1974 and is expected to furnish technology permitting the attainment of National New Source Performance Standards by the beginning of calendar year 1975. It should ultimately allow the attainment of average emissions of less than 300 ppm of NO$_x$.

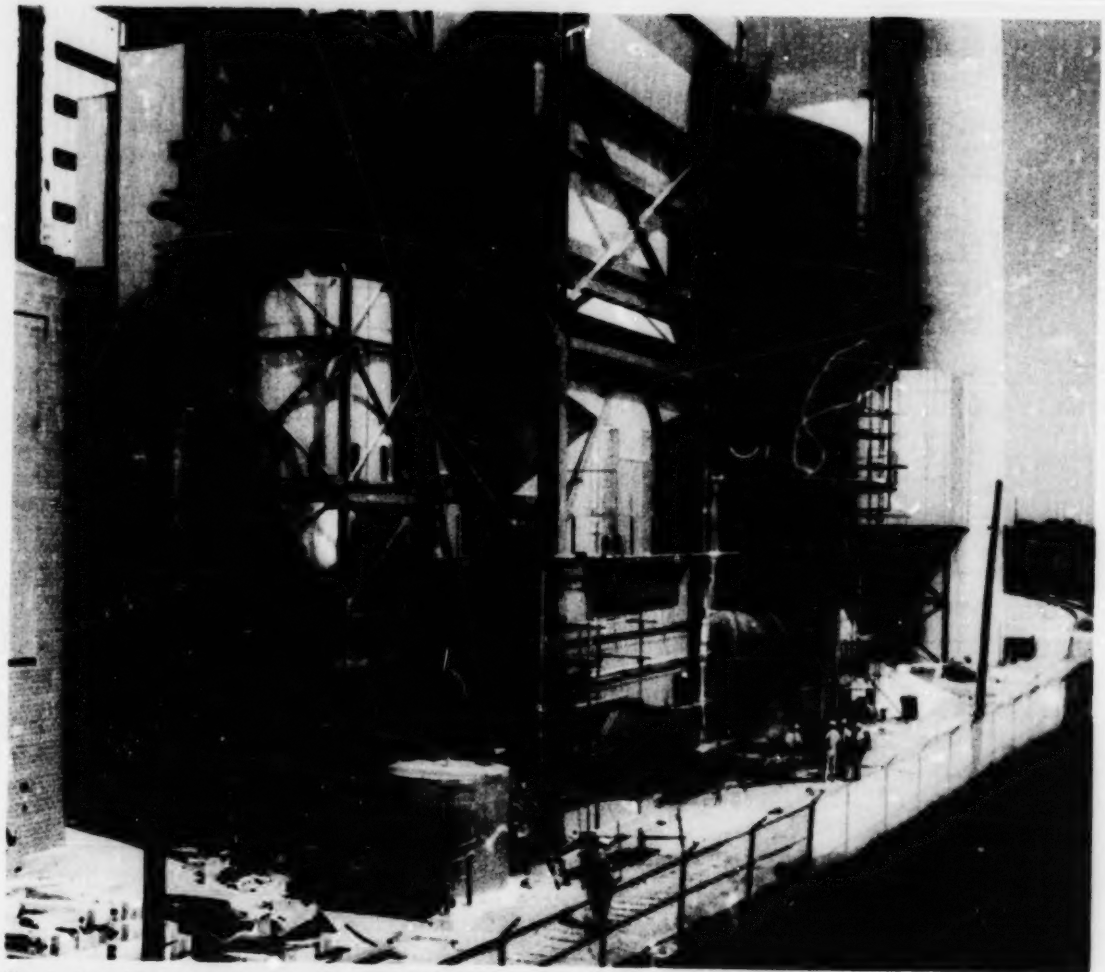
The basic research, which got underway at the beginning of calendar year 1974, is expected to provide technology to allow average emissions of 150 ppm NO$_x$ to be obtained in 1978.

Primary efforts during Fiscal Year 1974 will be the development and demonstration of modified operating procedures for NO$_x$ control on pilot- and commercial-scale boilers. The efforts of the overall combustion research and development program are classified under the main areas of fundamental studies, fuels research and development, process research and development, and field testing.

Fundamental Studies—A number of projects classified as fundamental research studies are directed at providing a basic understanding of the important phenomena involved in the formation and destruction of pollutants during the combustion process. This understanding can then be used to improve existing combustion control techniques and to suggest other techniques with even greater promise for control of pollutants. The fundamental studies cover three categories of work: the chemistry of pollutant formation and destruction, the physical processes of combustion, and the mathematical simulation of combustion.

The actual conditions existing within the flame zone are a function of the physical processes of combustion. Most combustors operate with diffusion flames where fuel and air are introduced separately and mixing is dependent on the manner of introduction. Because the flame zone is not of homogeneous composition, it is necessary to understand the role of combustion aerodynamics in pollutant formation. A contract with United Aircraft Research Laboratories has as its objective the establishment by detailed velocity mapping of the flow-field properties in an idealized single-burner combustor as a function of fuel and air inlet parameters. The local chemical compositions and the exhaust product composition will be monitored to show the effect of aerodynamic and mixing conditions. Future work in this area will include a study of the role of flame interactions in multiple-burner systems on the emission properties of the systems.

Because the chemical and physical effects of actual combustion are closely related, it is essential to provide a method of tying these effects together and generalizing the results for a variety of systems.



Catalytic oxidation process for sulfur dioxide removal is in operation at Wood River Power Station in Alton, IL.

Mathematical simulation of combustion by modeling is the tool used for this purpose. In the past year, work has been directed toward developing the necessary components of the model. Major effort has been expended in the development of a rapid computerized technique to allow evaluation of combustion kinetics of numerous simultaneous reactions, incorporation in the model of simplified flow fields, improvement of the turbulence model, and comparison of model predictions with cold- and hot-flow furnace data using simple chemical kinetics. Ultimately, the kinetics and fluid-flow programs must be applied together to give a realistic description of any practical system.

Fuels Research and Development--Fuels research and development studies are conducted on versatile experimental combustion systems. The studies are designed to develop generalized combustion control technology that is applicable to the control of NO_x and other combustion-related pollutants from conventional fuels, waste fuels, and future fuels. Studies conducted to date have been designed to develop combustion control technology for a specific fuel through single-burner design criteria on combustion modification techniques. These studies provide the future goals for NO_x control and will generate the necessary technology to be applied in the process research and development area.

Contracted studies with the Institute of Gas Technology (IGT) have been directed toward the relationship between combustion, aerodynamics, and pollutant emission characteristics of industrial gas burners. A recently initiated study with IGT will further investigate specific burner and process parameters and

Wet limestone (coral) scrubbing system for sulfur dioxide removal is in operation at oil-fired power plant in Key West, FL.

evaluate and optimize burner design to minimize NO_x emissions from natural gas firing. A new experimental furnace has been built for this program. The detailed experimental program will evaluate three classes of industrial gas burners. Detailed in-the-flame probing will be conducted to better understand the role of aerodynamics in pollutant formation. The experimental program and final report are scheduled for completion late in 1974.

The International Flame Research Foundation is under contract to develop combustion system design criteria for heavy oil- and coal-fired furnaces. Two series of experimental trials have been conducted to relate burner design parameters to pollutant emissions, flame configuration, and combustion efficiency. These trials have consisted of input/output measurements followed by detailed flame probing for a limited number of cases. Results to date have identified the types of flow conditions required to control formation of NO_x from pulverized coal.

Process Research and Development–CSL's process research and development work involves studies with commercial and prototype combustion systems for the application of optimum NO_x control technology. Results of these studies will provide the basis for the demonstration of combustion control technology. To date, the studies have considered all conventional fuels and combustion systems. The major emphasis, however, is in controlling NO_x emissions from coal-fired utility boilers.

Two major programs that will have significant beneficial impact are those related to combustion modifications of a 125-MW, tangentially coal-fired utility boiler (Combustion Engineering, Inc.) and a 125-MW, wall coal-fired utility boiler (Tennessee Valley Authority). Both programs will evaluate staged combustion as a control technique for NO_x with special emphasis on unit performance and fire-side corrosion.

Field Testing–CSL has sponsored several field test programs, with boilers ranging from residential to utility size, to determine what can presently be done to control NO_x and combustible emissions. This work is done on commercial equipment and is generally performed by research and development organizations familiar with the specific combustion systems being studied using the financial and technical assistance of manufacturers, users, and trade associations. In addition to developing trends and providing directional recommendations for industry to use to minimize emissions with today's technology, the work also defines where the research and development efforts should be concentrated by developing emission factors as a function of equipment type and size, and fuel consumed. The field testing studies are the initial efforts in the development of control technology and are designed to provide the state-of-the-art in control of NO_x and combustible emissions from existing commercial combustion systems.

A study with residential (up to 30,000 Btu/hr) and commercial (300,000 to 10,000,000 Btu/hr) boilers was jointly sponsored by the American Petroleum Institute (API) and EPA. Battelle Laboratories, the contractor, concluded that emissions from this size range of equipment can be controlled best by proper burner design and proper maintenance.

Field tests with utility (500,000,000 Btu/hr and greater) boilers have been performed by Esso Research and Engineering Co. During 1971, the first year of the tests, 17 boilers (25 boiler/fuel combinations) that fired coal, oil, and/or gas were tested. Depending on boiler design, NO_x reductions averaging 60 to 70 percent were achieved with gas-fired units, and 50 to 60 percent with oil-fired units: initially, reductions with coal-fired units were not as successful. NO_x reductions on the gas- and oil-fired units were primarily achieved through low-excess-air-firing and staged combustion. In the past 2 years, emphasis has been placed on coal-fired boilers. Esso was recently able to reduce NO_x emissions by an average of 40 to 50 percent by using low excess air and staged combustion on 12 coal-fired units without increasing other emissions or significantly affecting boiler performance. However, more information is needed to determine the effect of combustion modification with coal-fired units and tube-wall corrosion.

In the future, new burner designs will be tested in industrial and utility boilers, and testing will be conducted on such techniques as increasing fuel richness during staging of combustion. The effect on emissions of mixed-fuel firing and fossil-fuel/waste-fuel firing will be determined. Also, the effect of firing coal-derived fuels, such as low-Btu gas, will be investigated.

NO_x Program Summary–To date, it has been shown: that flue gas recirculation is the most effective combustion control technique for NO_x emission from nitrogen fixation of atmospheric nitrogen, and that staged combustion is the most effective control method for NO_x emissions from fuel nitrogen conversion. The development of this technology by the EPA has allowed the control of NO_x emission from gas- and oil-fired utility boilers to a level of 150 to 250 ppm. In short-term testing, combustion modifications have also resulted in NO_x reductions of up to 50 percent in commercial coal-fired utility boilers. In addition, burner and furnace design variables have been shown to cause widely varying NO_x emission levels in all boiler categories. Current efforts are directed toward the continued development and demonstration of modified operating procedures for NO_x control in pilot- and commercial-scale utility and industrial boilers. Future work will support the establishment of New Source Performance Standards by applying the control technologies, developed as a result of this research and development effort, to pilot- and commercial-scale demonstration of combustion control of NO_x for existing and new combustion sources in all size categories. In addition, the research and development effort will be extended to develop control technology applicable to the combustion of additional fuel types (including coal-derived fuels such as low-Btu gas, mixed fuels, waste fuels, and methanol) and covering a wider range of combustion equipment (e.g., stationary gas turbines, internal combustion engines, and industrial process furnaces).

Hazardous and Other Pollutant Control

As EPA's regulatory program has developed, the number of pollutants requiring control has expanded to include more than 30 potentially hazardous and/or annoying air pollutants. The overall goal relating to hazardous and other (other than SO_x, NO_x, and particulates) pollutants involves demonstration of the "best" technology for controlling pollutant emissions from specific combustion and industrial processes to such a degree that a net health benefit is realized with the least economic impact. Established technology can lead to setting New Source Performance Standards or Hazardous Emissions Standards.

Each of several hundred different industrial source types has a different degree of adverse environmental impact. The data base describing many of these source types is either non-existent or not in a form suitable for deciding on the need to develop control technology for the sources. A major effort is underway in CSL to generate the needed data base so that the environmental impact of the sources can be assessed accurately. Where currently installed control technology does not reduce emissions sufficiently for them to be of insignificant environmental impact, control technology must be developed. All options, including add-on devices, process changes, and raw materials changes, are considered in selecting the most attractive approach for technology development. The programs in the "hazardous' element then involve either source assessment or technology development.

The goal of CSL's highly source-oriented control program for hazardous and other pollutants is to control all pollutants from a given source. For convenience in presentation, the extremely diverse program can be divided into six source categories: organic chemical processes, inorganic chemical processes, ferrous metals processes, non-ferrous metals processes, open sources, and hazardous pollutants from combustion sources.

Organic Chemical Processes—In the area of organic chemical processes, CSL has three source characterization (assessment) programs underway: acrylonitrile manufacture, petrochemical flares, and hexachlorobenzene sources. The Laboratory also has four technology development programs underway involving: catalyst regenerators at refineries, pulp mill recovery furnaces, rendering plants (odor control), and ethylene dichloride plants. Projects are also underway to assess the economics of various sulfur control options at petroleum refineries.

Inorganic Chemical Processes—Relating to CSL's work with inorganic chemical processes, a program is underway to determine the need to develop control technology for fluoride emissions from gypsum ponds at fertilizer plants. Another ongoing project will provide data to quantify the capability of control equipment for enclosed asbestos sources: hopefully, this data will be used to strengthen the equipment standards for asbestos control.

Ferrous Metals Processes—The ferrous metals industry converts iron ore and scrap iron into useful iron and steel products. At large integrated steel plants, iron ore, limestone, and coke are charged to a blast furnace where the iron ore is reduced to molten metal, which is periodically tapped. The iron from the blast furnace is saturated with carbon that must be removed to change it into steel. The iron from the blast furnace, usually molten, is generally mixed with cold scrap in a steelmaking furnace where it is blown with air or oxygen, which burns the carbon, to produce steel. It is in the steel furnace that the carbon level is reduced to the required level, impurities are removed, and alloying agents are added. (Other, less important, steel-making furnaces are the open-hearth and the electric arc.) The steel from the furnace is poured into ingots that solidify. The ingots are then adjusted to proper and uniform temperature and physically squeezed into the desired shape in rolling mills.

This sounds simple, but in reality it is rather complex as there are many ancillary processes and operations to contend with; e.g., sintering, coke production, scarfing, and galvanizing.

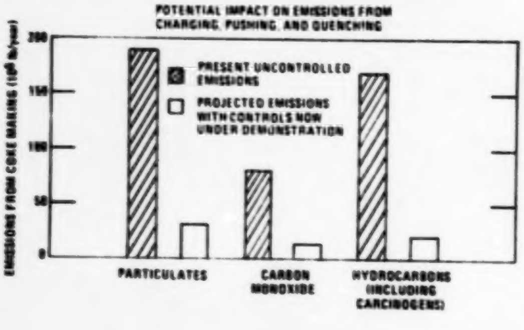
The iron and steel industry is not limited to large integrated plants: small iron and steel foundries are spread throughout the country. In these foundries scrap iron or steel is melted in electric arc and induction furnaces or in cupolas with little or no refining, then poured into molds to solidify into the desired shape.

Production of coke in conventional oven batteries has traditionally been a major source of particulates, SO_x, odors, carcinogens, and hazardous trace metals. It has been shown that top-side coke oven workers have a substantially higher risk of lung cancer than the average worker, probably from carcinogenic materials associated with the particulate fraction of the emissions. Until recently, emissions from this source have been relatively uncontrolled. Because the majority of existing cokemaking facilities will be operable for the next 25 years and because most facilities built in the next 10 years will feature conventional oven batteries, CSL has had to concern itself with developing control technology for conventional batteries in order to meet pollution control guidelines until the end of the century.

Present indications are that, even though pollution control technology may be developed for conventional batteries, equipment will probably be expensive and have high-maintenance cost, yet may not be able to control all pollutants. The expected long-term solution to the coking problem is a continuous coking process that emits pollutants in a more controllable form. CSL's involvement in coking is ultimately expected to encompass continuous cokemaking.

Specific coke oven emission control projects with CSL involvement include: smokeless coke charging, enclosed coke pushing and quenching, smokeless coke pushing, and improved coke oven door seals. As shown in the accompanying figure, CSL's prototype demonstrations are expected to permit reduction of coke oven emissions from coke production. CSL is now expanding its outlook–initiating projects in other areas of the industry, in addition to cokemaking. Other major CSL ferrous emission control projects are related to sinter plant windboxes, basic oxygen process (BOP) furnaces, and iron foundry cupolas.

	DEMONSTRATION COMPLETION DATE
SMOKELESS COKE OVEN CHARGING	FEBRUARY 1974
ENCLOSED COKE PUSHING AND QUENCHING	DECEMBER 1974
SMOKELESS COKE PUSHING	JANUARY 1974



Control technology demonstration–coke making.

Non-Ferrous Metals Processes–CSL's activities relating to non-ferrous metals processes -particularly relating to air pollution problems associated with primary copper, lead, and zinc production in the U.S.–began late in 1967 with a survey of sulfur oxides and particulate matter emitted by those industries. The study by Arthur G. McKee and Co., completed early in 1970, gave a general qualitative and quantitative status of emissions in the smelting industry.

The "McKee" effort was followed by another general study–this one to appraise the suitability of Monsanto's Cat-Ox process and the Wellman-Lord process for controlling sulfur oxide emissions from copper, lead, and zinc smelters. The study was performed by Stanford Research Institute.

Because U.S. copper smelting exposes a significant segment of the population to a multiplicity of pollutants whose effects have not yet been determined, efforts are underway to evaluate emissions from such plants. CSL has also initiated a set of development projects. Two new efforts currently being mounted have as their respective objectives:

- Providing smelter-by-smelter information to EPA on the optimum application of currently demonstrated technology to simultaneously control all smelter streams containing SO_2 and particulates. The output will be in the form currently being accepted by the courts as demonstration by means of technology transfer.
- Assessing the environmental considerations of emerging technology for metal-winning in the primary non-ferrous industry. In this project, consideration will be given to hydrometallurgy as a new smelting process.

CSL and Phelps Dodge Corporation started a cost sharing study in July 1971 on a new SO_x control method based on reacting the SO_2 with H_2O, with sulfur values recovered as elemental sulfur. Initial attempts to generate the needed H_2S by roasting available copper ore with steam at 800°C showed that, although it was technically feasible, the economics were prohibitive. The emphasis has now shifted to leaching the concentrate with hydrochloric acid, which decomposes the pyrite and/or pychloric in the concentrate and releases ample quantities of H_2S.

Preliminary results are promising; however, tests are required to understand the observed variations in H_2S generation as a function of the concentrate source.

EPA has entered into two separate Public Law 480 Agreements (excess foreign currency program) with Yugoslavia: one with the Institute for Copper, in Bor; and the other with the Lead and Zinc Institute in Trepca. The Bor project is a 3-year investigation (begun in May 1971) being carried out at an American-engineered copper smelter, the largest in Europe. The Trepca project is a similar 3-year effort (started in October 1971) being carried out at a lead and zinc smelter.

Objectives of both projects are:

- To characterize, quantitatively and qualitatively, all air pollutant emissions from this type of smelter.

- To relate air pollutant emissions to the smelter feed and to feed changes so that data will apply to other smelters.
- To relate air pollutant emissions to operational changes (changes in smelter configuration) so that data will apply to other smelters.
- To determine the effects of controlling sulfur dioxide and particulates on the emission of all other pollutants, especially of the "hazardous" heavy metals.

The relationships that are being developed in these two Public Law 480 projects are expected to be applicable to the domestic non-ferrous smelting industry.

CLS's interest in hazardous and other emissions from the non-ferrous metals industry prompted a study being performed at the South Dakota School of Mining under a research grant. The hazardous element of interest in this study is the mercury vapor or metallic mercury found in smelter or power plant flue gases.

Another CSL-funded effort relating to mercury and other hazardous pollutants (e.g., arsenic, cadmium, selenium, antimony, beryllium, copper, zinc, and lead) is a study by Monsanto Research Company to ascertain concentrations of these metals in smelter-produced sulfuric acid. Such a survey is intended to help predict the fate of hazardous pollutants produced by smelter sulfuric acid distribution to, and consumption by, different industries.

Open Sources–CSL's open sources program is a broad-based source characterization program, initiated to characterize all major sources of toxic emissions from mining and materials handling operations for the metallic ores and non-metallic minerals industries. Studies are underway: to identify heretofore unrecognized major sources of asbestos; to assess the importance of and develop control technology for asbestos mining sites; and to assess the importance of and develop control techniques for industrial wastes containing asbestos.

Hazardous Pollutants from Combustion Sources–CSL's program relating to the control of hazardous pollutants from combustion sources is closely coordinated with the Laboratory's particulate control, NO_x combustion, and SO_x flue gas cleaning programs. Because the initial emphasis is upon characterization of emissions from the most significant sources of pollution, the approach of the program is similar to that for industrial process control programs.

Coal-fired utility and industrial boilers were selected as being of highest priority. Midwest Research, selected as the contractor to characterize these sources for hazardous emissions, has developed a comprehensive test program covering all significant parameters that might affect toxic pollutant emissions. The program was prepared during 1973 with actual sampling beginning early in 1974.

In addition to the characterization of utility and industrial boilers, studies are being initiated to identify control alternatives for open combustion sources.

Energy Research and Development

A major effort has been underway since July 1973 to develop a plan for increased Federal support of energy research and development. As noted in the special Energy and the Environment section of this Report, the Control Systems Laboratory has provided substantial support to this planning activity and is expected to assume a major role in the implementation of the new energy programs. The accelerated development of new energy processes will require an extensive technology assessment function within EPA.

The expanded control technology research and development program will require increased budgets for EPA starting in Fiscal Year 1975. CSL is expected to assume the lead in managing these funds; the program will be implemented through interagency agreements and activities conducted by other EPA laboratories that are coordinated by CSL, as well as through direct contracts to the private sector.

The significance to EPA of this energy research and development function cannot be overemphasized. During the next 5 years, decisions will be made and technology will be developed that will firmly establish the basis for the generation of energy for decades to come. These new energy technologies must be environmentally sound if the future health and welfare of the Nation is to be protected. Although environmental considerations may be subjugated to short-term energy needs, there must ultimately be a reconciliation of energy and environmental considerations.

Active involvement by EPA will ensure that environmental control systems keep pace with new energy processes.